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Facilitating teacher professional learning : analysing the impact of an Australian professional learning model in secondary science

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FACILITATING TEACHER PROFESSIONAL LEARNING: ANALYSING THE IMPACT OF AN AUSTRALIAN PROFESSIONAL LEARNING MODEL IN SECONDARY SCIENCE.

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ABSTRACT

In education, innovations are frequently introduced to promote changes to the curriculum, teachers' practice, and the classroom environment, however, these initiatives are often implemented without sufficient evaluation to monitor their impact and effectiveness in bringing about the desired changes.

This thesis analyses the impact of a teacher professional learning program on lower secondary science teachers' practice. It examines the relationship between teachers' concerns about the strategies incorporated in the Collaborative Australian Secondary Science Program (CASSP) and teachers' ability to understand the strategies, on their ability to utilise those strategies in the classroom. It also seeks to determine teachers' beliefs about their current science teaching practice and how this is different from their beliefs about ideal science teaching, and also, how these beliefs direct teachers' classroom practice. Finally this study describes a number of primary and secondary factors found to impact on teachers' professional learning. The CASSP model encapsulates the primary factors of curriculum exemplars (curriculum resources), explanation and modelling (professional development), and reflection (participative inquiry). The secondary factors include ensuring adequate time for change to occur, student support and participation, peer teacher support, support from leaders including heads of department, support from the school administration and support from state education officers.

This study has demonstrated that teachers' professional learning is a complex process that is strongly influenced by teachers' beliefs, concerns and understandings, and is impacted by the primary and secondary factors identified by the research. Teachers must be able to envision the advantages of incorporating new strategies into their existing practice, and consequently seek to make these changes to their teaching. This study has shown that students are also an important influence the implementation of an innovation, without their support, teachers are unlikely to make successful changes to their teaching practice.

Implications of the research include the need to elaborate the CASSP professional learning model to include the secondary factors identified in the study, and the need to

inform students about innovations so that they can see the benefits for them in terms of improved learning outcomes.

SIGNED DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

(i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;

(ii) contain any material previously published or written by another person without due reference;

(iii) contain any defamatory information.

Signed: [redacted] ____________ Date: 10-11-04

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My long-suffering husband, Gerry, who hopes to get a home cooked meal now this thesis is completed.

My family and friends, who have endured my enthusiasm and self-doubt with patience and encouragement.

DEDICATION

This thesis is dedicated to:

The four case study teachers who volunteered to participate in this study, as without their support and enthusiasm this project would not have been possible.

My two sons, Luke and Michael and my grandfather, William Sheffield.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: OVERVIEW

Introduction

> The basic responsibility of science teachers in all grade levels is to ensure that as many students as possible understand science and technology to a degree that will make them feel at home in the modern world and enable them to make informed decisions about important questions that deal with scientific matters.
>
> (Moore, 1988, p. 445)

Goodrum, Hackling and Rennie's (2001) report on *The Status and Quality of Teaching and Learning of Science in Australian Schools* concurred with Moore's (1988) view of the central role that teachers play in an effective science education. In fact, of the nine recommendations in their report, five relate to teachers. Any worthwhile initiatives instigated to improve science education need to be accepted, understood and supported by teachers. Time, energy and resources must be expended to create meaningful and appropriate teacher professional development. Teachers should be committed to, understand and be confident with the proposed approaches and strategies, if they are to implement them effectively in the classroom. Failure to follow this protocol will result in poorly implemented innovations with little or no relevance to teachers or students (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

This research aims to examine the impact of a teacher professional learning model, the Collaborative Australian Secondary Science Program (CASSP) in supporting a professional development innovation with a small group of Western Australian secondary science teachers.

Background

Need for Change

Fensham (1985), Millar and Osborne (1998) and Moore (1998) report that students are not choosing to study science as they find it complex and uninteresting. Moore (1988) states that students perceive science to be "a bewildering set of unrelated facts and an over-whelming terminology all to be blindly memorized" (p. 445). These findings have been confirmed by Goodrum, Hackling and Rennie's (2001) review of science education in Australian schools. They canvassed a wide range of views and opinions regarding science education from all major stakeholders including teachers, students, scientists and members of the community. The results revealed a considerable disparity between an ideal picture of secondary science education and the actual science teaching and learning practices in Australian schools. A chasm has appeared between the ideal: relevant, engaging, investigative, enjoyable and interesting science taught by enthusiastic and committed teachers with plenty of resources, and the actual: boring, irrelevant, chalk and talk lessons punctuated by cookbook laboratory exercises taught by educators who felt "undervalued, under resourced and overloaded" (Goodrum et al., 2001 p. viii). It has become obvious that there is a need for change to close the gap and bring the actual picture of science education closer to the ideal picture.

The science curriculum experienced by most Australian secondary students is focused on preparing students for university science programs. Teaching 'elite science' for those students who intend a career in a scientific area has been at the expense of many students who do not see the relevance of science for them, and do not choose science subjects in upper school (Fensham, 1985). Science programs should accommodate the needs and interests of students from a wide range of cultural backgrounds and abilities, which develops

> the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs and economic productivity.
>
> (National Research Council, 1996, p. 2)

Ideas regarding the science skills and understandings required by citizens, that researchers have been expounding since James Conant's reform efforts at the end of World War II, have become encapsulated in one term, scientific literacy. The National Research Council (1996) articulates a vision of the entire American population becoming more scientifically literate. They argue that in the current technologically advancing world, citizens need to be able to draw on their science skills and knowledge to make key decisions about their futures, their careers and their lifestyles. Increasingly, scientific literacy has been identified as the most important of the key elements in current science education. In fact, it has been recommended by researchers that the purpose of science in the compulsory years of schooling should be to improve students' scientific literacy (Bybee, 1997). The OCED Programme for International Student Assessment (1999) has provided a broad encompassing definition

> Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (p. 60).

Perceptions of the needs of students have changed, particularly as we enter a new age in which science and technology play a larger part in our world and it is now recognised that all students need a quality science education to prepare them for life. Fensham (1985) and Bybee (1997) argue that a new curriculum is needed that is designed to be more inquiry orientated, and contextually based with strong links to the everyday environment. The curriculum should develop the skills and attributes that are deemed necessary for scientific literacy. It would seek to combine scientific skills with a reduced number of relevant scientific concepts in a pathway that is continuous from K-12. Students' progress through the curriculum framework should be at their own rate matched to their conceptual level, to ensure understanding and not just memorising of scientific concepts.

Key Elements Identified as Necessary for Effective Teaching Practice

Along with the new curriculum, there are a number of key elements that have been recognised as being vital in the development of effective teaching and learning. These key elements were highlighted in a report entitled *National Science Education Standards* presented by the National Research Council (1996). Although the report identified scientific literacy as the primary goal for the science education of American students, it also identifies a number of other key elements. These elements support and promote scientific literacy, and provide strategies that teachers can use to guide students to become more scientifically literate. These key elements are identified as the use of constructivist teaching strategies to promote student understanding, the use of inquiry-based science programs to engage students in meaningful learning, and the use of assessment to direct and augment learning.

Inquiry has been identified as a key element that increases the effectiveness of teaching and learning Goodrum et al., (2001). The National Research Council (1996) defines scientific inquiry as

> the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (p. 23).

Inquiry is a powerful tool for learning as it is based on individuals' curiosity about the world around them. Teachers need to build on students' natural curiosity to

> help all their students understand science as a human endeavour, acquire the scientific knowledge and thinking skills important in everyday life and, if their students so choose, in pursuing a scientific career.
>
> (National Research Council, 2000 p.6)

The notion of inquiry and investigation encapsulates the true essence of the way scientists think and perform experiments in their professional lives. The ability to gather data, interpret results and make judgments about the validity of data presented by others provides the individual with the skills needed for decision-making in their everyday lives.

It is imperative that students take control of their learning, are not passive observers in the classroom, and actively seek to select and process new information in order to make sense of their world. Teachers must therefore create environments that challenge students' prior knowledge and promote the active collecting and processing of new data (Davis, JoMcCarty, Shaw, & Sidani-Tabbaa, 1993; Nussbaum & Novick, 1982; Stofflett, 1994). For this process to occur effectively teachers must teach for understanding, and this requires a movement away from old 'chalk-and–talk' teacher-centred methods towards practices that promote learners' participation and engagement with learning, which subsequently fosters increased understanding. As Doyle (1983) contends, changing the way students learn is not always popular with the students themselves, who often vehemently resist teachers' attempts to change their practice and subsequently their classroom learning (Doyle, 1979).

Another key element of effective teaching is the manner and type of student assessment. In the review *Beyond 2000: Science Education for the Future*, Millar and Osborne (1998) expressed their concerns about typical classroom assessment:

> While there has been some changes in the forms of assessment used, too much of the summative assessment of students is still based on factual recall and bears little relationship to the sorts of situations beyond the classroom, where students may need to apply their scientific knowledge and skill.
>
> (Millar & Osborne, 1998, p.4)

Teachers also need to develop new skills and strategies for formative assessment, which can be used fruitfully to reveal students' existing knowledge and skills and allow teachers to guide learning more effectively (R. J. Osborne & Wittrock, 1983). Assessment must be designed to demonstrate students' understanding and not just regurgitation of rote-learned information. For example the ever-popular multiple-choice questions reduce student learning to a collection of remembered isolated facts and in answering these students do not necessarily demonstrate understanding (Goodrum et al., 2001). Assessment also needs to be focused on the outcomes of science education that contribute to increasing students' scientific literacy.

Teacher Change

As Black (1993) states

> ... it must be recognised that teachers are the sole and essential means to educational improvement. If they do not share the aims, and do not want to do what needs to be done, it cannot happen effectively.
>
> (Black, 1993, p. 45)

The new wave of educational reforms requires teachers to have a wide range of sophisticated skills to implement the new curriculum frameworks. Teachers need to be equipped to make decisions about students' progress in the continuum leading to learning outcomes. Teachers need to stand aside in the classroom to allow the focus of education to shift from teacher-centred learning to student-centred learning. Teachers need to become retrained as facilitators who have the skills to determine the level of understanding of learners and plan a series of encounters for learners to enable them to be engaged and excited as they progress towards greater understanding. Teachers are the most important factor in improving learning, consequently time and resources must be invested to help them make the necessary changes to their teaching practices. It is vital that teachers have the necessary understanding of curriculum content and pedagogy, to enable them to respond to the needs of the learners.

To encourage teachers to learn new skills and more effective strategies, teacher educators must consider teachers' needs as learners. Teacher educators must promote an environment that will motivate teachers into becoming life-long learners, who are enthused, interested and responsible in improving their learning. In the same way as teachers facilitate students' learning, providing them with a sense of ownership and responsibility, so teachers must be furnished with the same sense of ownership and responsibility for their learning. Teachers' learning must be fostered in a similar constructivist environment to the one that the teachers seek to create in their own classrooms for their students (Loucks-Horsley et al., 1998).

Teachers' beliefs have been identified as being very influential in directing teachers' classroom practice (Fang, 1996; Pajares, 1992). Consequently in order to foster teachers' learning and influence their practice, research must focus on teachers' beliefs as these beliefs will determine how innovations are implemented into the classroom (Cronin-Jones, 1991). Researchers need to probe teachers' beliefs to determine their beliefs about the nature and purpose of secondary science teaching, their beliefs about what constitutes ideal classroom practice and how these beliefs differ from teachers' actual classroom practice. Concerns arise from the discrepancy between teachers' beliefs about ideal teaching and learning and teachers' actual practice (Hall & Hord, 1987). These concerns help foster cognitive dissonance between teachers' beliefs and practice, creating a potential environment for learning and change. The initial conceptual framework (Figure 1.2) recognises the importance of teachers' beliefs about teaching and learning and how differences between beliefs and teachers' current classroom practice create concerns.

Using the Collaborative Australian Secondary Science Program (CASSP) to Facilitate Teacher Change

The CASSP model is unique in that it draws together three distinct elements and interweaves them to produce a comprehensive approach designed to bring about prolonged and sustained teacher change (Hackling et al., 1999a). These elements are professional development, reflective and collegial participative inquiry for teachers, and curriculum resources that embed and exemplify the desired teaching practices (Figure 1.1).

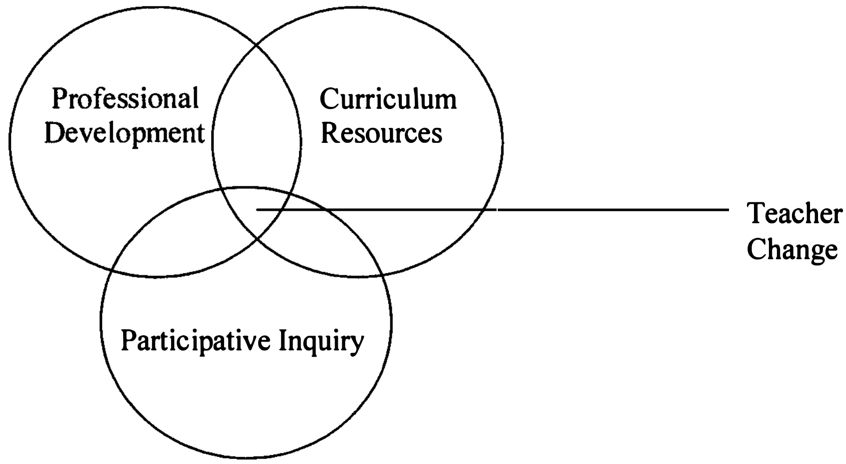

Figure 1.1. The relationship between the three components of the CASSP model (Hackling et al., 1999a).

The CASSP teacher change model was adopted for a national 'proof of concept' trial funded by the Commonwealth Department of Education, Training and Youth Affairs. The national trial of the CASSP model was implemented in all Australian States in Term two of 2002 (Goodrum, Hackling, & Trotter, 2003). The CASSP trial focused on bringing about more student-centred learning based on constructivist principles, inquiry and investigative approaches to learning, and increase the use of more formative, developmental and authentic approaches to assessment (Goodrum et al., 2003).

The Process of Teacher Change

Loucks-Horsley et al., (1998) the process of change is not a single event or a single unsupported strategy, but rather an on-going process, which occurs over weeks, months and even years. Understanding the change process and the concerns of the teachers exposed to change, can allow the change facilitator to instigate interventions to increase the success of the innovation being adopted (Hall & Hord, 1987). This thesis seeks to examine the impact of CASSP innovation on the Western Australian teachers participating in the CASSP trial in 2002, and in particular on four teachers who were the subject of case studies.

Hall and Hord (1987) highlight the stages of teacher change in their Concerns Based Model (CBAM), which can be used to map an individual teacher's journey through the change process, from non-user to a competent user. The stages of concerns which Hall and Hord (1987) developed can be used to analyse the teachers' understanding of the innovation and also their levels of use. More recently this has been modified (Dlamini et al., 2001) to produce typologies of teacher change that can be used to map the teachers levels of understanding and their levels of use of the innovation.

These stages of change models (Dlamini et al., 2001; Hall & Hord, 1987) provided a framework for evaluating the success of the CASSP trial. The models allowed the Researcher to analyse the process of change in terms of teachers' level of concerns, understanding and use of the innovation.

As previously noted, teachers are not passive observers of change. Without teachers' enthusiasm and interest in pursuing new teaching practices and embracing a new framework for education, there will be only trappings of a new system with teachers' core beliefs and practices remaining untouched.

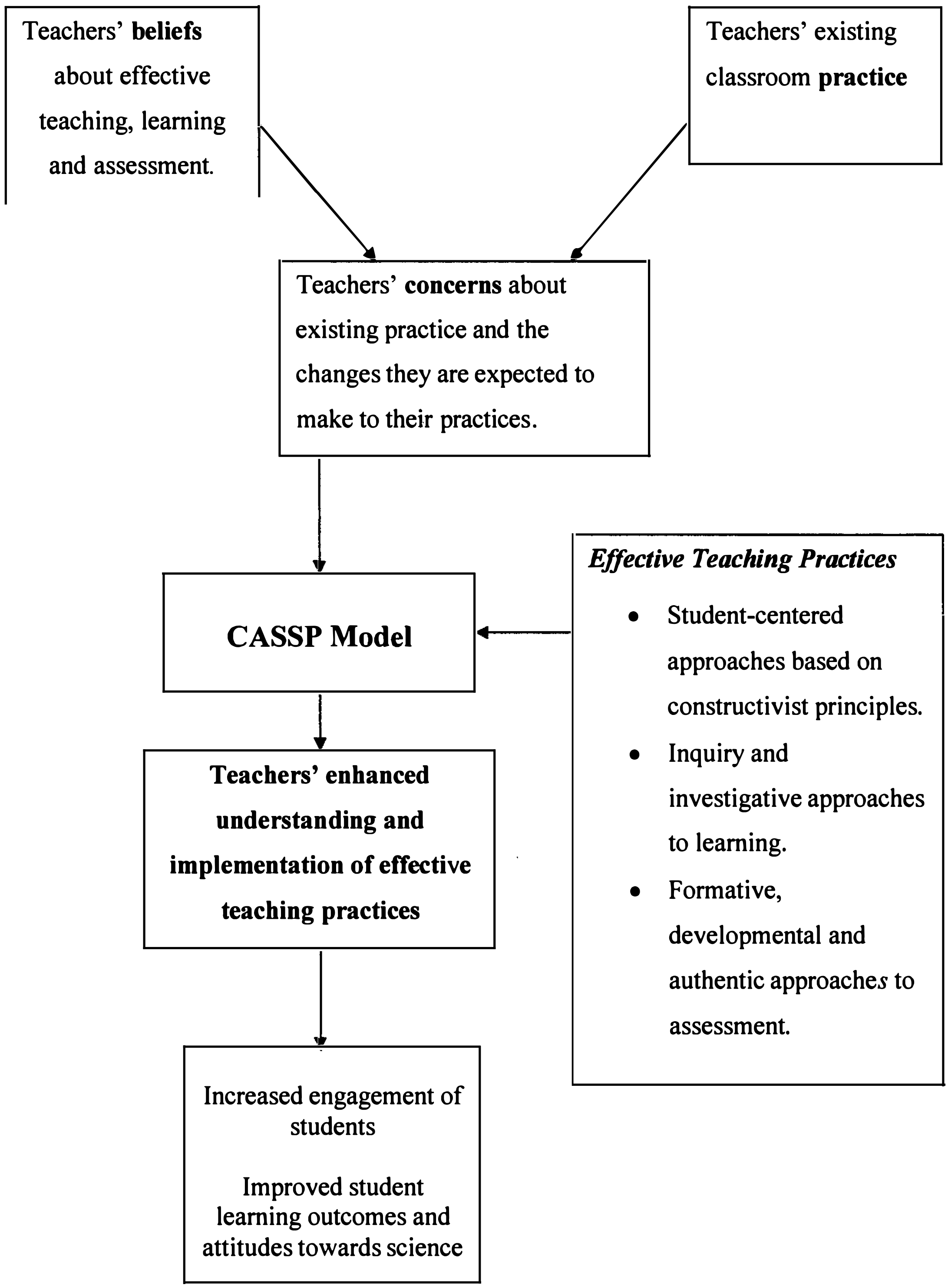

Fig 1.2. Initial conceptual framework developed for the study

Problem

In education, innovations are frequently introduced to promote changes to the curriculum, teachers' practice, and the classroom environment, however, these changes are often implemented without sufficient evaluation to monitor their impact and effectiveness in bringing about the desired change.

There is a need to initiate major changes to Australian science education to improve the effectiveness of teaching and learning, make science more interesting and relevant and enhance students' scientific literacy (Fensham, 1985; Goodrum et al., 2001). The CASSP model was designed to guide the development of professional learning programs that will support teachers to change their practice. In this study the impact of the CASSP professional learning program on teachers and their teaching practice was closely monitored and analysed to determine its success and identify those factors that influenced its effectiveness.

Rationale and Significance

Teachers play a pivotal role in the introduction and implementation of new strategies into the classroom, consequentially it is vital that they understand and endorse any proposed innovation. The Collaborative Australian Secondary Science Program (CASSP) has been designed to promote and support teacher change. The CASSP model is unique in that it integrates components of professional development, curriculum resources and participative inquiry to promote change in teachers' classroom practice.

This study seeks to make an original contribution to the teacher professional development literature by monitoring and evaluating the new CASSP approach to teacher professional development. The study examined, in depth, a small number of teachers as they experienced the innovation, and mapped these teachers' concerns, use and understanding of the innovation to predetermined typologies (Dlamini et al., 2001; Hall & Hord, 1987). The study seeks to provide valuable insights into factors facilitating and inhibiting teacher change in response to the CASSP program so that teaching and learning can be improved. The study examined students' experiences during the CASSP trial, to determine the impact of the Program on their engagement and learning in science. Research findings will also be used to refine the CASSP model and program resources for use in a full-scale Australia-wide implementation in Years 7-10.

Research Questions

Overarching question

What impact does the CASSP program have on teachers' beliefs and practices, and what factors influence these changes?

Subsidiary research questions

1 What **beliefs** about teaching, learning and assessment do teachers bring to this study?

2 What **concerns** about teaching, learning and assessment did teachers have at the beginning of the innovation? How did the **innovation specific concerns** change during the implementation of the CASSP professional learning model?

3 To what extent do teachers **understand** the theory, philosophy and teaching practices associated with the innovation?

4 How successful are teachers in **implementing** the innovation?

5 What **factors** inhibit or facilitate a change in teaching practice?

6 What are **students' attitudes** towards the innovation, and what are students' attitudes towards science?

Definition of Terms

Concern

"Is the composite representation of the feeling, preoccupation, thought and consideration given to a particular issue or task" (Entwistle, 1981; Hall & Hord, 1987, p. 58-59). Consequently to be concerned is to be in a mentally aroused state about something, the intensity of the arousal will depend on the person experiences and how immediate the issue is perceived to be.

Beliefs

> A set of conceptual representations which signify to its holder a reality or given state of affairs of sufficient validity, truth or trustworthiness to warrant reliance upon it as a guide to personal thought or action.
>
> (Fang, 1996, p. 49)

CASSP Model (Collaborative Australian Secondary Science Program)

This is a teacher professional learning model developed by Hackling, Goodrum and Deshon (1999b) to promote a change in teachers' classroom practice. It incorporates three components, professional development, curriculum resources and participative inquiry

Engagement

In this thesis, student engagement is defined as not only time on task but also the extent to which students are interested and involved in science learning experiences.

Innovation

Defined as any new project that is being introduced to the teachers' classroom. In the case of this thesis, the innovation is the strategies provided by the CASSP model interwoven around the Year 9 Energy unit and delivered in three components; curriculum resources, participative inquiry and professional development.

Participative inquiry

This is defined as the formalised process of ongoing reflection by the teachers participating in the innovation during the innovation. The participative inquiry meetings provide opportunities for ongoing reflection, collaborative problem solving by science teachers, and the construction of new professional knowledge (Reason & Bradbury, 1994).

Professional development

In the context of this thesis the term professional development relates to the three workshops conducted by an external facilitator at the beginning, middle and end of the CASSP trial. All trial teachers participated in these workshops, which modelled and discussed effective teaching and learning strategies. The professional development with the participative inquiry and curriculum resources formed the basis of the CASSP program

Scientific literacy

> the capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions, investigate and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well being. (Hackling, Goodrum, & Rennie, 2001, p. 15)

Professional learning journey

A term used to describe teachers' ongoing professional learning and development and their professional practice.

Constructivist learning strategy

Constructivist learning strategies start by considering students' existing ideas and then provide students with opportunities to explore phenomena and develop their own explanations so they can construct their own meaning guided by the teacher.

Inquiry learning

Inquiry emphasises a teaching approach that works from questions through data interpretation and explanation, and forms one of the many constructivist strategies.

Summary

This Chapter articulates the conceptual framework in which the study is set, identified the need for the proposed changes to teachers' practice, highlighted those practices identified as best practice and briefly examined the professional learning model CASSP (Hackling et al., 1999a). The outline also examined the framework chosen to monitor teacher change, including stages of concerns, levels of understanding and levels of use (Dlamini et al., 2001; Hall & Hord, 1987). The Chapter has articulated the problem that the thesis seeks to address, operationalising it in one overarching question divided further into six subsidiary questions. The Chapter also provided definitions for all the important terms used throughout the thesis.

CHAPTER 2: LITERATURE REVIEW

Introduction

This Chapter is divided into seven sections. The first section, **the need for change**, provides evidence, that demonstrates there is need for change in the teaching, learning and assessment of science in Australian schools.

Section two, **an ideal picture of science education in Australia**, investigates exemplary teaching practice and presents the ideal that educators are striving towards.

Section three**, an actual picture of science education in Australia**, examines the nature and purpose of lower secondary school science currently taught in Australian schools. The current status of science education is then compared with the ideal.

Researchers have identified a number of key attributes of excellent teaching practice, those are discussed fully in section four, **improving the quality of science education**. These attributes include scientific literacy, constructivist learning, the nature of science, assessment and construction of the curriculum framework. The acceptance and subsequent adoption of these approaches to teaching and learning depends on the teachers' understanding of them and their ability to embrace and incorporate them into their beliefs and consequently their practice.

The fifth section, **teachers as the key to educational change**, examines the importance of teachers, their beliefs, their complex workplace demands, their pedagogical content knowledge, and their commitment to being life-long learners.

Section six, **facilitating teacher change**, reviews the nature of change, the use of professional development to support teacher professional learning, examines the CASSP model and considers the factors identified as impacting on teacher professional learning.

In the final section of this review, section seven, **monitoring the effect of teachers' professional learning innovations**, the stages of change models used to evaluate teacher change are introduced. The modified Concerns-Based Model by Hall and Hord

(1987) and Dlamini et al. (2001) that has been chosen to monitor the impact of the CASSP innovation are considered here in detail.

The Need for Change

> Education, at the end of the 20^{th} century, no longer prepares individuals for secure, lifelong employment in local industry or services. Rather, the rapid pace of technological change and the globalisation of the marketplace have resulted in a need for individuals who have a broad general education, good communication skills, adaptability and a commitment to lifelong learning. Our view is that the form of science education we currently offer young people is outmoded, and fundamentally is still a preparatory education for our future scientists. An advanced technological society such as ours will always require a supply of well-qualified research scientists, but this requirement will be met, as at present, by educating and training only a small minority of the population. On the other hand the ever growing importance of scientific issues in our daily lives demands a populace who have sufficient knowledge and understanding to follow science and scientific debate with interest, and to engage with the issues science and technology poses – both for them as individuals, and for our society as a whole.
>
> (Millar & Osborne, 1998, p. 1)

In their report *Beyond 2000: Science Education for the future*, Millar and Osborne (1998) highlighted and articulated the major concerns of researchers and science educators world-wide. In a shared consensus, key stakeholders in education are concerned about the nature of school science. As Millar and Osborne contend "future society will need a large number of individuals with a broader understanding of science both for their work and to enable them to participate as citizens in a democratic society" (Millar & Osborne, 1998, p. 4).

Visionaries have seen the gap between existing classroom science and the needs of the future citizens, as a guiding light that can steer science education towards major educational reform. Researchers in the United States have already identified the need for educational reform. Gibbs (1999 p.70) in his article for *Scientific American* interviewed Aikenhead who reported a need to teach "science that people needed to know for decisions that adults actually make, whether they were judges in court cases, politicians on planning committees, poor people budgeting for energy costs or parents who have children with special medical conditions". Aikenhead reported that he and his colleagues found classroom science in the United States as unrealistic, abstract and consequently useless in preparing students for future needs.

In 1952, James Conant introduced the idea of a general science education for all students, not just for the 'science elite'. He proposed that citizens require a strong base of applied scientific knowledge, with less emphasis on pure abstract scientific knowledge. He argued this knowledge would enable citizens to "be able to communicate intellectually with men who were advancing science and applying it, at least within certain boundaries" (Conant cited in Bybee, 1997, p. 47). This idea gathered momentum, becoming known as scientific literacy, and has subsequently become the major aim of science education. Scientific literacy embodies all these ideas and values of the purpose of science education, and is encapsulated as

> The capacity for persons to be interested and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions, and investigate and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well being.
>
> (Hackling et al., 2001, p. 15)

In order to redirect American science education, considerable review and consultation was undertaken with all the major shareholders in science education. This culminated in the introduction of the draft *National Science Education Standards* by the National Research Council in 1991. This document expressed a vision for education, particularly of scientific literacy as the goal for science education, and has "become the driving force behind improvements in US Science education" (National Research Council, 2000, p. xv).

Many researchers in both the United Kingdom and the United States have articulated the need for a new curriculum to support the introduction of scientific literacy. In 1988 in the United States, Moore (1988) suggested a thematic approach to the teaching of the science curriculum, to ensure a balanced and engaging approach. He also suggested that educators provide a continuous curriculum from primary to secondary levels. Further investigation was completed over the next few years culminating in the introduction of an outcomes-based curriculum with an emphasis on scientific literacy. The resultant report by the National Research Council (1996) *National Science Education Standards* outlined the standards for the new curriculum. In the United Kingdom, Millar and Osborne (1998) identified the need for a new more coherent and continuous curriculum.

They have determined that the current curriculum is no longer relevant to the needs of current and future students. The present curriculum is a body of knowledge, value-free and detached, and reported by Millar and Osborne as "a succession of facts to be learnt, with insufficient indication of any overarching coherence and a lack of contextual relevance to the future needs of young people" (p. 4). Millar and Osborne (1998) argued that a new curriculum needs carefully chosen objectives designed to engage and enthuse students, and subsequently foster the building of a set of values designed to help students understand the science of the world around them. Millar and Osborne's (1998) proposed curriculum incorporates the use of a wide variety of teaching strategies that include short periods of intensive learning of new ideas followed by consolidating with long-term investigations. Another of their proposals suggested the use of stories to help contextualise scientific concepts.

In 1989, Australian state, territory and federal Ministers of Education agreed on common goals for education and that a national curriculum framework and assessment framework comprising profiles of outcomes statements be adopted by each learning area. Following the publication of national curriculum and assessment framework in 1994, state and territories began to develop modifications of these national frameworks to suit their particular visions of education. These new curricula have a number of common features, including; a commitment to scientific literacy; a focus on outcomes; a focus on improvement for each individual student at their own level of achievement; improved student understanding; and competence with the processes of science.

The Status and Quality of Science Education in Australian Schools

Drawing from the research conducted in the United States and United Kingdom, Australian researchers set out to determine the status and quality of science education in Australian schools. Goodrum, Hackling and Rennie (2001) were commissioned, firstly to report on the status of school science education, and secondly to receive input from all major shareholders on what an ideal picture of science education relevant for the children of the future, would look like. Their report commissioned by the Australian Government's Department of Education, Training and Youth Affairs, entitled *The Status of Teaching and Learning of Science in Australian Schools*, provided an in-depth picture of teaching and learning in Australian science education in 2000. It has become an important reference point on which to base all further studies and innovations. The review allowed all the major stakeholders in Australian science education to have input into the production of the report, resulting in a unique collaborative effort. The stakeholders included the profession represented by the Australian Science Teachers Association (ie. ASTA), the Australian Academy of Science representing scientists, government education departments, universities, principals, classroom teachers, students and members of the community.

Submissions regarding teaching practice and the status of science education were sought from teachers, students, administrators, scientists and community representatives, and collected through Australia-wide focus groups, questionnaires and telephone surveys. Focus groups were established; one in each state and territory convened by the Australian Science Teachers Association were composed of teachers; a group was convened by Curriculum Corporation and was made up of members of the wider community, and the Australian Academy of Science convened a focus group of professional scientists. These groups sought to address issues regarding the nature of effective teaching and learning, determine the factors that inhibited teaching and learning and build up a picture of current classroom practice. Over 500 teachers from around Australia were sampled by telephone survey to gauge their views on current and ideal teaching practice. Goodrum et al. (2001) also collected over 4000 primary and secondary students' experiences and ideas about science in the classroom in the form of written questionnaires. To ensure no member of the community was excluded from submitting their views about the status and quality of Australian science education, letters were sent to 25 professional organisations across Australia, and advertisements were placed in the *Australian Science Teachers Journal* and on the Internet (EdNa) inviting individuals and organisations to make a submission to the review. Finally, 13 case studies of exemplary teaching practice were compiled (Goodrum et al., 2001).

An Ideal Picture of Science Education in Australia

From an analysis of their research data, Goodrum, Hackling and Rennie (2001) synthesised the following nine themes to describe the characteristics of the ideal picture of science education. These are:

1) The science curriculum is relevant to the needs, concerns and personal experiences of the students.

2) Teaching and learning of science is centred on inquiry. Students investigate, construct and test ideas and explanations about the natural world.
3) Assessment serves a purpose of learning and is consistent with a complementary to good teaching.
4) The teaching-learning environment is characterised by enjoyment, fulfilment, ownership of and engagement in learning, and mutual respect between teacher and students.
5) Teachers are life-long learners who are supported, nurtured and resourced to build the understandings and competencies required of best practice.
6) Teachers of science have a recognised career path based on sound professional standards endorsed by the profession.
7) Excellent facilities, equipment and resources support teaching and learning.
8) Class sizes make it possible to employ a range of teaching strategies and provide opportunities for the teacher to get to know each child as a learner and give feedback to individuals.
9) Science and science education are valued by the community, have high priority in the school curriculum, and science teaching is perceived as exciting and valuable, contributing significantly to the development of persons and to the economic and social well-being of the nation.

(Goodrum et al., 2001, p.viii)

The characteristics of effective science teaching and learning, have been identified in other studies including the Victorian *Science in Schools* project (Tytler, 2001), and Deakin University Consultancy and Development Unit Faculty of Science, Geoff Beeson, & Briter Solution (2003) and the professional standards developed by the Australian Science Teachers Association National Science Standards Committee (2001). Their research findings identified many criteria similar to those of Goodrum et al (2001), which are deemed essential for effective teaching and learning. These include; increasing the relevance of science to students needs and interests (Tytler, 2001); foster students understanding and use of science in their lives (Australian Science Teachers Association National Science Standards Committee, 2001; Tytler, 2001); developing a deeper understanding of scientific concepts (Australian Science Teachers Association National Science Standards Committee, 2001); promote the use of investigation and all forms of scientific methodology to solve scientific problems (Australian Science Teachers Association National Science Standards Committee, 2001; Tytler, 2001); catering for individual student needs (Tytler, 2001); and, employ a wide range of assessments designed specifically to complement learning strategy

(Australian Science Teachers Association National Science Standards Committee, 2001).

An Actual Picture of Science Education in Australia

In order to determine the actual picture of science education in Australian primary and secondary schools, Goodrum et al. (2001) conducted over 500 telephone interviews with practising teachers; surveyed over 4000 students in Years 5-11; compiled 13 case studies of best practice; reported on two rounds of focus group meetings of scientists, teachers and interested community members; invited submissions from all stakeholders; and, reviewed all pertinent literature. Focus group participants, questionnaire and telephone interviews respondents were asked to describe the typical teaching and learning practices, to list factors that inhibit quality teaching and learning of science, and determine how these factors could be addressed to improve the teaching and learning of science in Australian schools.

The emerging picture of secondary science education is bleak. Goodrum et al. (2001) found that many lower secondary students experienced a science that was unrelated to their interests and concerns. Many science classrooms were very teacher-centred, in fact 61% of the secondary students surveyed stated that they copied notes from the board or overhead nearly every lesson, while only 9% of students reported time was set aside every lesson for investigations. Forty-three percent of surveyed students reported they never went outside the classroom to perform science, 84% percent of students had never had anybody other than their teacher talk about science and 35% of students reported never learning about what scientists actually do. Science was deemed almost always irrelevant to 19% of students, never useful to 18 % of students surveyed, and for 31% of students science almost never dealt with things that that they considered important.

Teachers explained that curricula were mainly assessment-driven, with the focus on information taught for purely assessment purposes, which they felt left them little if any time to focus on processes and skills. Teachers reported feeling stifled by the overbearing nature of assessment, leaving them with no opportunities to be creative or imaginative. Forty-one percent of teachers surveyed also felt that they needed more time to collaborate and reflect on their teaching practice. Forty-three percent of teachers reported a lack of resources, with 19% of teachers experiencing overcrowding in classrooms, which limited their ability to focus on individual students (Goodrum et al., 2001). Teachers were often faced with classroom management problems which often "disrupt the teaching and learning relationship providing challenges for teachers trying to provide quality classroom experiences for the mix of students and learning styles" (Goodrum et al., 2001, p. 86).

Participants in the study also felt "the curriculum in place in most schools does not engage these secondary students as they find it difficult to see the relevance of science to their present lives and employment prospects" (Goodrum et al., 2001, p. 90). This sentiment is echoed by Millar and Osborne (1998, p. 5) who report that even the successful science students "lack any familiarity with the scientific ideas which they are likely to meet outside school".

As well as describing classroom experiences, teachers also reported on teaching as a profession. They were experiencing low morale, feeling undervalued, poorly paid with little public recognition, and explained their work was impinging on their family life. The 1994 Third International Mathematics and Science Study revealed that 50% of Australian mathematics and science teachers would prefer a change in career and leave teaching (Lokon, Ford, & Greenwood, 1996). Fewer science teachers were entering the profession, and many of the current teachers were nearing retirement age. There were indications that a shortage of teachers may occur in the near future unless more can be done to induce young, skilled professionals to join the teaching profession (Goodrum et al., 2001; Ingvarson & Loughran, 1997).

Improving the Quality of Science Education

A number of key elements have been identified as vital to improving science education and these are considered here. The primary element is the notion that the main purpose of school science education is to produce scientifically literate citizens and consequently the first section examines **scientific literacy**. The following sections define the elements that support the quest for scientific literacy. These include **constructivist learning, the nature of science, investigation and practical work, assessment,** and the **construction of the curriculum framework.**

Scientific Literacy

The need for individuals in our society to have a greater understanding of the science and technology of the world around them was identified by Millar and Osborne (1998). It has become urgent that science educators rethink the content of science taught in schools. Laugksch (2000) sees the future of nations depending not only on the quality and quantity of the scientists produced but also on the support for, and understanding of science by the wider community.

Traditionally science has been perceived as an elitist subject taken by few students in the post-compulsory years of their schooling, with the majority of students feeling inadequate and uninterested in science, and consequently not attempting any advanced science. Most students see the present science curriculum, as a very large number of isolated and socially unimportant concepts and facts crammed into a small time frame, which do not relate to students' everyday experiences. Fensham (1985) sees this as mirroring science educators' priorities and often repeating their own experiences as science students. Although Fensham (1985) acknowledges there is the need for a small proportion of students to do 'elite science' and become the scientists of the future, he feels that all the students need to be more scientifically literate, participating in a more encompassing general science education which extends to all levels of the curriculum. He argued that

> science education should produce more members of the society who will be able to benefit from the personal and social implications of science and will be prepared to support the changes of a scientific and technological kind that are needed for a good balance between development and environmental concerns (p. 417).

There has been concern, however, that the term 'scientific literacy' was being defined very loosely by many, consequently making it extremely hard for teachers and students in classrooms to achieve this nebulous ideal (Bybee, 1997; Laugksch, 2000). A number of researchers have been influential in defining 'scientific literacy' in a more stringent and consequently more usable way. These include Conant (1952) and Pella (1966) whose extensive literature review resulted in six characteristics of individuals who are scientific literate; these were later expanded to seven by Showalter in 1974 (Showalter, 1974 cited in Bybee, 1997). In 1975, Shen (1975) organised scientific literacy into three categories: practical science, to solve practical everyday problems; civic science, to make decisions in public issues; and cultural science, to understand the major issues. In this later category Shen (1975) only saw a very small proportion of the population, mainly in the intellectual community, who needed cultural science.

Branscomb (1981) further clarified the definition by reorganising and expanding Shen's categories. Miller (1983) proposed a multidimensional view of scientific literacy and sought to extend the vision of scientifically literate students to scientifically literate adults. He described three attributes that were important; understanding of the nature of science; science content knowledge; and the impact of science on society.

Bybee (1997) constructed an extremely detailed framework of scientific literacy, a framework with both horizontal and vertical depth. He proposed that individuals who did not have the cognitive capacity to understand scientifically based concepts whether due to age or mental development existed at one end, at illiteracy. Consequently as individuals progressed they became nominally literate (defining an idea or concept as scientific, but having no further understanding), functionally literate (use scientific ideal within a limited context), conceptual and procedurally literate (understanding conceptual relationships within science and can apply process of inquiry) and finally multidimensional literate (possessing an understanding of the integral nature of science and the relationship between science and the wider culture). These progressions are not limited to students within a school environment; they are designed to encompass all members of society as life-long learners. Bybee (1997) also noted that scientists may have highly developed ideas in the area of science in which they are experts, however, they have a much more limited depth of knowledge in other areas, this discrepancy gives the framework its changing depth within a horizontal dimension across areas of knowledge.

In reviewing the extensive literature in this area, and the subsequent consensus as to the importance of scientific literacy, the National Science Council (1996) and the National Research Council (2000) in America proposed a number of definitions of scientific literacy. The National Research Council (2000) in the *National Science Education Standards* extended previous definitions to detail the specifications of scientific literacy for teachers, students and the broader community.

> Scientific literacy means that a person can ask, find or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversations about the validity of the conclusion. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express opinions that are scientifically and technological informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. Individuals will display their scientific literacy in different ways, such as appropriately using technical terms, or applying scientific concepts and processes. And individuals will have differences in literacy in different domains, such as more understanding of life-science concepts and words, and less understanding of physical-science concepts and words (p.22).

There is no consensus definition of scientific literacy and its application in the classroom, however, it is acknowledged as an important mechanism to improve the relevancy of science education and subsequently increase students' interest. For students' future, Bybee (1997) has determined three major goals for the learning of scientific literacy; to ensure personal growth and development, to prepare citizens for their future role in society, and to give individuals the skills necessary for one or more occupations. For the purpose of this study set in an Australian context the definition from Hackling et al. (2001) which is based in Australian science education, will be used.

> the capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions, investigate and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well being
>
> (Hackling et al., 2001, p. 15)

Constructivist Learning

It has long been established that children are not 'empty vessels' to be filled with the appropriate knowledge that teachers choose for them to learn. Understanding the mechanisms of learning provides teachers with directions for improving teacher-learner interactions.

To construct knowledge, learners must actively and selectively attend to sensory information presented to them. They then construct a meaning for the information by inventing or selecting a model that organises the information in a way that makes sense to the learner. Learners use information stored in their long-term memory to determine what sensory information to attend to, their existing knowledge and prior experiences also shape how they process the newly acquired information and make sense of it (Nussbaum & Novick, 1982; R. J. Osborne & Wittrock, 1983). This process requires effort and motivation on behalf of the learner, as Osborne and Wittrock report, "learning science is something only a learner can do" (R. J. Osborne & Wittrock, 1983 , p. 498).

All students including those who have had no formal science instruction bring to the science classroom a set of ideas (prior knowledge), which they have created to help them to make sense of the world around them (Nussbaum & Novick, 1982). These prior conceptions are often very different from the concepts held by scientists (R. J. Osborne & Wittrock, 1983). Due to the students' use of their prior conceptions when interpreting new information, the interactions in the classrooms are shaped differently for different students, consequently resulting in diverse learning experiences for each child. Students often leave the classroom with new conceptions that are totally unlike those expected by the teachers (Nussbaum & Novick, 1982; R. J. Osborne & Wittrock, 1983).

There are several outcomes, listed below that can arise from teaching and learning in science, and only the last is the result expected by many teachers:

1) The original concept remains unchanged and the new concept rejected.
2) Two vastly different concepts exist to explain the phenomena, one is close to the 'experts view' of science and the other, the child's view. These are so diverse that they can co-exist without impacting on each other.
3) The new concept is incorporated into the original conception but form a newly generated concept that is still vastly different from the 'expert views'.
4) The student accepts the new concept and the old concept is discarded, and the resultant conception is closer to 'expert views'

(Nussbaum & Novick, 1982; R. J. Osborne & Wittrock, 1983).

Conceptions that are quite different from expert views are known as alternative conceptions or misconceptions (Nussbaum & Novick, 1982). Learners often hold onto these alternative conceptions very tenaciously. As a consequence new concepts must be intelligible (make sense to the learner), plausible (seen as true by the learner) and fruitful (can be used by the learner to solve problems) (R. J. Osborne & Wittrock, 1983; Posner & Strike, 1992). When a new concept meets all these criteria, and there is dissatisfaction with the old conception, a conceptual change may occur which produces a new conception, which is closer to 'expert science' ((Hewson & Hewson, 1984). Students, however, often form concepts to explain the everyday world that are very practical and consequently very fruitful and enable them to explain ideas (ie. gravity, friction) in a way that makes sense to them even though different from the accepted scientific explanation. When science is not grounded into every day situations (ie. contextualised) students are not likely to see the 'expert view' of science as being plausible to explain the everyday event that they encounter (MacBeth, 2000).

Teachers' play a vital role in transforming students' understanding. It has long been realised that the task of teaching for conceptual change is a complex and multifaceted one. Researchers have determined that there are four forms of constructivist relationships that exist between teachers and their students. Teachers can identify and understand the type of relationship that exists between them and their students in the science classroom (Watts, Jofili, & Bezerra, 1997). The first relationship is called 'power-on', where the learning is teacher directed, although the teacher is aware of the students' prior conceptions the teachers' agenda is rigidity adhered to. The second form is 'power-off' which is the opposite to 'power-on' where the learning is totally student directed, with teachers holding a bystander position. The most powerful and profitable relationships between student and teacher are 'power-for' and 'power-with' relationships. These relationships involve the teacher working with students, to empower the student to construct their own understanding (Watts et al., 1997). Ritchie (1998) also shares this vision of teachers working alongside students "to help students explore and make sense of the network of ideas within and across the disciplines of science" (Ritchie, 1998, p. 169). A practical application of this is an *interactive approach*, which involves negotiation between the teacher and student on whether students' questions can be successfully investigated, and how they should approach the investigation while keeping it based within a familiar context. In this way the teachers' role is to advise and discuss rather than dominate the learning (Ritchie, 1998).

Ritchie (1998) entered the fray with concerns that researchers and teachers were developing the notion that constructivist and more traditional terms were mutually exclusive. He felt that teachers should not be limited to using a single approach in the science classroom. He argued that learners use multiple strategies, both constructivist and traditional, to construct meaning. Constructivist terms (share, facilitate and negotiate) and more traditional terms (show, tell and demonstrate) could be used together to increase students' understanding.

MacBeth (2000) advocates that teachers should increase their familiarity with the language and traditions of their students. Consequently teachers capture the

> ... 'cultural capital' of young children, which finds their ways of speaking in the home, their familiarity with reading, letters and numeracy; and their sense of larger, normative worlds of narrative structure, scenic description, and common wisdom, as deep resources that contributes to their success of the classroom
>
> (MacBeth, 2000, p. 233)

Besides using language and other culturally familiar props in which to ground the lesson, teachers are encouraged to determine students' prior conceptions when seeking to effect conceptual change. A number of techniques have been developed to probe student understanding; they include student interviews (Gilbert, Watts, & Osborne, 1985; J. Osborne & Cosgrove, 1983), computer-assisted instructional packages (Hameed, Hackling, & Garnett, 1993), two-tier multiple-choice tests (Rowell, Dawson, & Madsen, 1993; Treagust, 1988) and word associations (White & Gunstone, 1992). Nussbaum and Novick (1982) focus largely on exposing students' prior conceptions in their instructional strategy. They seek to encourage students to articulate their prior conceptions, by using an 'exposing event'. Students then describe these prior conceptions in written and verbal forms. Students must then debate the pros and cons of their conceptions and determine the limitations and usefulness of their conceptions. Nussbaum and Novick (1982) then advocate creating a 'discrepant event' which demonstrates how the student's prior conceptions are unable to explain an observed phenomenon, creating cognitive dissonance, this conflict can then be dissipated by promoting discussion of the event and help the students to shape and formulate a new conception.

These ideas of Nussbaum and Novick (1982) have been refined and expanded to form a model, the *Instructional Model for Contemporary Science Education* (also known as the 5Es model) (Bybee, 1997). This model has evolved and developed from more simplified models. Bybee (1997) identifies five stages to the model, Engagement, Exploration, Explanation, Elaboration and Evaluation (hence the 5Es). Engagement is similar to Nussbaum and Novick's 'exposing event', it seeks to focus students on a specific idea or question to explore, and to elicit existing concepts. The concept to be investigated must be contextualised within the students' familiar surroundings, and linked to students' prior experiences. Once students have become actively engaged in the problem, they need to explore their ideas and subsequently move into the exploration phase. Bybee (1997) advocates that the teacher acts as a facilitator in this phase, providing the framework for the activity, but allowing the students to explore freely. Teachers are encouraged to listen to students' ideas, use questions to redirect students thinking, provide time and concrete resources for students to explore their ideas, and encourage students to collaborate in team groups. Once students have explored their ideas then they are required to articulate and explain them in the explanation phase. Students seek to demonstrate their understanding of the ideas and concepts that they have been examining. Formal definitions can be introduced at this time, and teachers encourage students to explain and justify their ideas. The elaboration phase of the model challenges students to develop deeper understanding of the concepts, incorporating formalised definitions into their own explanations and provides opportunities to apply the new concepts to a range of contexts. Finally students are encouraged to evaluate their understanding and abilities, and teachers seek to determine students' progress. Teachers provide a rich array of assessment situations to allow students to demonstrate their understanding and apply their skills in different contexts (Bybee, 1997).

Although students construct their own learning, teachers are of vital importance to the learning process. Teachers must be active thinkers who reflect about the teaching and learning that occurs in the classroom (Watts et al., 1997). In order to be effective in the classroom, teachers need to access all teaching strategies, traditional and constructivist, and adapt them to the students and the situation.

The Nature of Science

Curriculum in the United States has been described as being 'a mile wide and an inch thick', intimating that it contains large quantities of facts with little or no depth of understanding. Differences also exist in the content of science curricula state-to-state and even district-to-district. A similar situation has been identified in Australia, with differing objectives and aims for science education embedded in the curriculum of the States and Territories. All stakeholders, however, are in agreement that defining and articulating the nature of science and determining how it should represented in science curricula is important to enable students to become 'intelligent consumers of scientific information and effective local and global citizens' (M. Smith & Scharmann, 1999, p. 493).

This has led to wide and enthusiastic discussion of the nature of the science taught in schools, with some educators favouring an emphasis on inquiry and of science processes while others favour an emphasis on content knowledge, the products of science. The *Definition and Rationale of Science Education* written by the Western Australian Education Department defines science as:

> a dynamic, collaborative human activity that uses distinctive ways of valuing, thinking and working to understand natural phenomena. Science is based on people's aspirations and motivations to follow their curiosity and wonder about the physical, biological and technological world around them. Scientific knowledge represents the constructions made by people endeavouring to explain their observations of the world around them. Scientific explanations are built in different ways as people pursue intuitive and imaginative ideas, respond in a rational way to hunches, guesses and chance events, challenge attitudes of time, and generate solutions to problems. As a result of these endeavours, people can use their scientific understanding with confidence in their daily lives.
>
> (Curriculum Council of Western Australia, 1998, p. 218)

The definition articulates the uniqueness of the processes and skills of science and their role in increasing students' understanding of their world. For some educators this dynamic use of science to solve problems and explain phenomena is the core of science and they feel that it should be heavily emphasised in the science classroom (Lederman, 1992). There has been an ongoing discussion between two perspectives, those that argue that the curriculum should emphasise the processes of science, and those that argue that the curriculum should emphasise the facts or products of science. Supporters of the product faction advocate that science content knowledge has the greatest value for learners. Within the product or knowledge faction, there are a number of minor factions. Some factions argue for the inclusion of the historical perspective to promote greater understanding of the nature of science, which should be very different from the current recital of dates and names. Other factions promote teaching only contemporary science, the science of the moment e.g. biotechnology, cloning. While others advocate science that is based in pre 1900s, covering scientific discoveries and technology of the era.

The National Research Council promotes inquiry as a way for students to learn to design and conduct scientific experiments and to increase the "understanding they should gain about the nature of scientific inquiry" (National Research Council, 2000, p. xv). In Australia, one strand of the new curriculum, *Working Scientifically* is devoted to scientific processes. This strand incorporates skills for students from K-12 to develop their abilities to practice science, as well as transferring learnt skills to different conceptual areas within the science curriculum. Incorporating long-term investigations into the curriculum demonstrates to students how the processes of science can be utilised.

Smith and Scharmann (1999) have proposed a set of characteristics of science. They argue that science is:

a) Empirical – based on observation and seeks to find out about the natural world.
b) Testable/falsifiable – data can be collected that can support or refute each claim.
c) Repeatable – ensuring an experiment can be repeated by others to reach the same results.
d) Tentative/fallible and self-correcting – science is constantly being updated and changed as research is carried out.

The way that science is presented in schools should reflect these characteristics if students are to develop an understanding of the nature of science itself.

Investigation and Practical Work

Hodson (1990) argues that traditional approaches to practical work are "ill-conceived, confused and unproductive" (p. 33) and that teachers use practical work without considering how it is used and whether or not it achieves the aims and expectations they have set for it. Practical work has also been subjected to complaints that it does not resemble real scientific investigations. Due to the limited time and resources available students often perform science experiments that require following a prescribed recipe e.g. cookbook science, rather than problem-solving, inquiry-based science. If these recipes did not 'work' ie. show the answer the book has told students to expect, teachers were forced to change results or explain what should have happened to students, leading students to believe that science does not work (Hodson, 1990; Lederman, 1992). Students are not given opportunities of ownership of the experiments they are performing and consequently are not intellectually challenged or interested by their experiences.

Although the design and purpose of current practical work has been maligned by many researchers (Hodson, 1990), most teachers feel that practical work is important and worthwhile. Some teachers feel that practical work provides opportunities for language development, working cooperatively, stimulating natural curiosity and motivation and fun. While others see it as providing students with opportunities to develop problem-solving skills, increase manipulative skills when using scientific equipment, and for providing experiences of natural phenomena that can lead to improved conceptual development (Hackling, 1998; Hodson, 1990; Lederman, 1992). Concerns about the nature and purpose of practical work, and research findings that show that typically secondary science students have few opportunities to plan their own experiments has resulted in a call to introduce open investigations into the curriculum (Hackling, 1998; Staer, Goodrum, & Hackling, 1998). Garnett, Garnett, and Hackling (1995) argue that *investigation*s provide opportunities for students to take the initiative and find solutions to problems. They describe an investigation as

> a scientific problem which requires the student to plan a course of action, carry out an activity and collect the necessary data, organise and interpret the data, and reach a conclusion which is communicated in some form
>
> (Garnett et al., 1995, p. 27)

The inquiry-based investigations in the WA curriculum are designed to be variable in their length and in their openness. At the lowest level of inquiry the problem, equipment, procedure and answer to the problem are all given to students and the students must verify the solution presented. While in the most complex form the student determines all the questions to be investigated, and the equipment and procedure to be used, with guidance from their teacher (Hackling, 1998). If investigations are embedded in familiar contexts, they are more relevant and meaningful for students, and provide an authentic experience of science. Solving these problems would require students to plan their experiments and use problem-solving skills, skills that students do not currently use in their present practical work (Hackling, 1998). Inquiry-based investigations are compatible with the 5Es instructional model, working on the premise that students' learn more effectively when they interpret new experiences based on their prior experiences and construct their own understanding of their experiences.

In the Australian curriculum the *Working Scientifically* strand provides opportunities for investigative work to contribute to the understanding of the other conceptual strands. The investigative form of practical work offers students the "opportunities to use skills and concepts and put them into practice in a context with a goal or purpose in mind" (Duggan & Gott, 1995, p. 146).

Students need to appreciate that science is a dynamic subject that is being used by scientists to make sense of the world. Furnishing students with inquiry-based skills and processes will enable them to apply the science processes they have learnt in the classroom to problems they experience in their everyday life, or use them to critically examine the validity of claims made by others about scientific matters in the media.

Assessment

There has long been a contention that assessment, particularly summative assessment, has been the driving force of the curriculum. Teachers report that they feel pressured to teach a vast amount of content knowledge to prepare students for tests and exams, especially in the Year 12 public examination subjects. This results in students gaining a very superficial understanding of science (Goodrum et al., 2001). Studies found that this pressure resulted in a number of detrimental effects including: a reduction in the cognitive level of understanding of science by students; a breaking down of the concepts into simplistic isolated fragments; teaching with a focus on the test content rather than curriculum objectives; lack of time for students' questions; reduction in the contextualisation of the concepts; continuation of "chalk and talk" teaching methods; and a reduction or cessation of investigations and practical work (Black, 1993). It is clear that teachers and principals need to review the purpose and nature of assessment for the student, teacher, and school and in the wider community. It is already argued that the wider community perceive that students are leaving school with an irrelevant assessment certification as it does not document the necessary skills for future employment (Black, 1993). There is a perception that the important things that should be assessed are, not the isolated fragments of abstract concepts, but group-working abilities, communication skills, problem-solving skills and higher-order thinking abilities. These skills are perceived by employers in the workforce as being extremely important for prospective employees.

According to Black (1993) the purposes of assessment are threefold; to support learning, to report the achievement of individuals, and to satisfy public accountability of the teacher and the school. It is the second and third of these purposes that are seen to be the most important as the second, can impact on the students career options and the third relating to accountability can affect the status and employment of the teacher and the status of the school. These two summative forms of assessment, however, do not contribute to teaching and learning in the classroom, which is the purpose of formative assessment.

Formative assessment is an under utilised mode of assessment, however, it has the power to monitor learning and provide feedback to students in the science classroom. It is the single most important factor in promoting constructivist teaching and learning. It enables the students to reflect on their progress, and becomes a very powerful tool in increasing the students' conceptual understanding and increasing and maintaining their motivation. Formative assessment also allows the teacher to determine the effectiveness of the teaching strategies they are utilising, enabling the implementation of new teaching strategies where it is perceived that learning is not occurring effectively. Formative assessment can provide teachers with new approaches to determining students' learning progress, and to bring a greater sense of collegiality between student and teacher as it becomes more obvious both are attempting to improve students' understanding. Black and William (1998) reviewed a wide range of studies of the use of formative assessment. They concluded that "these studies show that innovations which include strengthening the practice of formative assessment produces significant and often substantial learning gains" (Black & William, 1998, p. 142).

Teachers can use concept maps and brainstorming activities to determine prior conceptions or to help the student organise the new material s/he has acquired. Portfolios are also an example of an alternative form of assessment for teachers. They entail students and teachers choosing the work that students submit and display; often several drafts are included to show development. When students are able to choose which pieces to submit it increases their commitment to their own learning. Portfolios can also be used to communicate to parents and the community the actual work being created in the classroom, and this encourages children to take pride in their work. Portfolios can be associated with a students' journal, where students are encouraged to reflect on and clarify their ideas, and record their thoughts and feelings about activities and experiments, this also helps the teacher to determine the effectiveness of instruction.

The use of criterion-referenced or standards-referenced assessment will also help to increase the feedback to teachers about the position of students on the learning continuum. Currently most schools assess and report on students' achievement in a norm-referencing framework, where a student is compared with his/her peers rather than identifying what the student knows. Criterion or standards referencing determines students' progression by monitoring their progress through a number of pre-determined levels of performance. Black (1993) discussed a common difficulty with the nature of the criteria used to define the levels of performance. If they are too broad and vague, then they are no longer useful. If they are too "specifically defined then teachers become burdened by the sheer number required to assess a single idea" (Black, 1993, p. 58).

There is also the problem with the terminology used to indicate the progression through the criteria, it needs to demonstrate the idea of a progression without losing the concise nature of the criteria, and avoiding terms such as 'greater understanding' or 'understand thoroughly' being employed. Consequently it was suggested that teachers and curriculum developers band together specific criteria and use the achievement of a number of criteria within the band to indicate the level of success achieved. In order for criterion referenced forms of assessment to be relevant, there needs to be stringently defined learning outcomes specified in the curriculum. Although explicit outcome standards for judging levels of achievement have been articulated, teachers are concerned about their abilities to reliably determine student levels. Parents and the wider community are concerned that the move away from the present grading system will create confusion about student abilities and achievements (Black, 1993; Goodrum et al., 2001). If this method of assessment is to be effective, time and resources must be allocated to ensure parents and the wider community clearly understands the criteria and how these relate to students' achievement in science.

There needs to be a fresh approach to assessment as well as an innovative new curriculum to help students learn in a more productive way. Formative assessment using criterion-referenced assessment focused on outcomes that contribute to scientific literacy become can enhance learning. As Goodrum et al. (2001) have summarised,

> with the implementation of an outcomes-focused curriculum, the role of assessment in promoting learning becomes critical. Learning is cumulative and assessment should allow learners' progress to be monitored. Assessment tasks should be developed as part of the teaching and learning program so that they reflect the learning outcomes for science and match the needs and levels of development of the students. Assessment must be designed to assess students' understandings and skills as well as their knowledge (p.21).

Construction of the Curriculum Framework

Changes in the curriculum must be implemented to allow students to strive for scientific literacy. As previously stated there is a need to increase the relevance of the science taught, to make it more interesting and useful to students and increase the number of students completing science to high levels. Millar and Osborne (1998) suggest that 'explanatory stories' can be used to contextualise and clarify the scientific concepts included in the syllabus. They describe these stories as providing students with an understanding of not just a single concept but a range of inter-related ideas, which "provide a framework for understanding an area of experience" (p. 5) and not detract the learner with copious quantities of individualised knowledge statements. Although extensive filling of the curriculum with copious amounts of information, even in story format, will result in a content-dominated curriculum which will not leave sufficient time for further discussion, analysis and reflection (Goodrum et al., 2001; Millar & Osborne, 1998). A new curriculum needs to be developed, that is compelling to all students, that it is socially and individually relevant to students and achievable at some level by all (Fensham, 1985). Fensham (1985) catalogued areas of content for a new and relevant curriculum, of which knowledge is only one of the areas, others include; application of knowledge, intellectual skills, practical skills, problem-solving, science attitudes, science and technology application, and personal needs.

In order to increase the number of students who attempt science at upper secondary level, Fensham (1985) proposed that schools reorganise their science curriculum. He envisaged retaining elite science at the higher levels of the school program in the post compulsory years, and implementing a new more relevant and general science in the compulsory years of schooling. Complex, conceptually difficult scientific concepts would be removed from the lower compulsory years, as students are unable to understand them at this level. Fensham (1985) argues that presenting students with these difficult concepts repeatedly does not increase students' understanding of them. Consequently Fensham (1985) argued a containment point should be established in science education, which would divide the science curriculum and would be based on the needs of students. Below the containment point in the lower years of compulsory education all students should experience the same general science curriculum. Above Fensham's (1985) containment point in the post-compulsory education, students could either study elite science (ie. physics, chemistry etc.) or a parallel curriculum with reduced conceptual goals to elite science. Fensham (1985) contended it was important that students in the post-compulsory years continued with science education either in an elite form for career purposes, or a more general science education to improve students' scientific literacy.

Science curriculum frameworks in Australia

Following in the footsteps of North American and British curriculum writers in the 1980s, Australian educators identified a need for an outcomes-based curriculum. The subsequent formation of the Australian Education Council (AEC) in 1986 was accompanied by the articulation not only the need for a new curriculum, but also for a truly national curriculum. This was to provide students across Australia with a consistent identical education from K – 12. *The Common and Agreed Goals for Schooling in Australia* was a landmark report by the AEC in 1989, and over the next few years statements and profiles were developed. By 1993, the AEC Curriculum and Assessment Committee had produced eight sets of statements and profiles, one for each of the learning areas. The statements set out the framework for learning encompassing content, processes and concepts. The profiles describe the progression of learning in eight levels of achievement. These profiles will provide a common framework for assessing and reporting student achievement (Goodrum et al., 2001).

Due to changes in the political environment, work on the National Curriculum was halted in 1993. Subsequently the statements and profiles have been superseded by new curriculum frameworks developed by individual States and Territories and reshaped to suit each educational jurisdiction. There are a number of principles, which are common to the science curricula developed by the Australian States and Territories. The first principle is the rationale that science is important, useful and relevant to all students. All students must be engaged and interested as life-long learners, to explore science that will help them make decisions about their life-style, their health, their education and their future. This in essence defines scientific literacy, and emphasises its importance in peoples' lives. The second and third principles relate to the importance of outcomes in the curriculum. Educators are not longer interested in what students have been taught *en masse*, but rather what individuals have learned. Outcomes specify not only what students should know but also more importantly how they should be able to demonstrate and apply these skills and knowledge. The outcomes-based continuum from level to level is designed to enable the teacher to chart the learning progress of each individual student. The curriculum is also designed to provide a wide range of science concepts, organised in four conceptual strands. These strands are *Energy and Change, Life and Living, Earth and Beyond* and *Natural and Processed Materials.* Students learn knowledge and skills through a process of inquiry, which is the next underlying principle of the Australian curriculum frameworks. How we do science is extremely important and consequently the skills that enable students to investigate, plan, collect data, interpret and analyse scientific information are an important aspect of the science curriculum. The *Working Scientifically* strands with the other knowledge areas and provides students with the methodology of the doing of science (Goodrum et al., 2001).

Teachers are encouraged to design teaching and learning programs that encompass the learning outcomes at the appropriate level for their students. They are also required to connect the science learning area with other learning areas and provide a contextualised program linking in with the students' everyday experiences, not just isolated abstract facts. Curriculum developers have embedded criterion-referenced outcomes-based assessment in the framework, enabling students to progress through levels at a rate consistent with their conceptual abilities. This formative outcomes-based assessment supports and promotes the constructivist ideology underpinning the teaching and learning. To be successfully implemented, the new WA Curriculum Framework requires teachers to introduce a wider range of new teaching, learning and assessment strategies into their classroom. Effective learning requires students to be motivated and interested learners, who are able to achieve understanding, not just a regurgitation of facts, and who see information as useful and relevant to them in their everyday pursuits.

Teachers have an extremely difficult task ahead of them to make the necessary changes outlined for an improved education system. These professionals, however, are life-long learners, with strongly held beliefs who have strong pedagogical content knowledge, numerous classroom skills and who are committed to the students in their science classes.

Teachers as the Key to Educational Change

Hattie (2003) reviewed the research about factors that influence students' achievement, the largest source of variance is students' prior knowledge and ability. The second largest source of variance is what teachers know and do. Improving teachers practice, therefore, has the potential to make a significant difference to students' learning (Hattie, 2003).

Teachers are in a unique position, in the isolation of their classrooms, having primary control of their teaching and learning environment. Due to this isolation, Cuban (1990) speculates that classrooms are not subject to the pressure of reform exerted higher in the administration of education. He sees teaching as "insulated from the externally driven pressures for fundamental change" (p. 11) and describes teachers' actions when introduced to an innovation

> They can introduce innovative materials designed by outside consultants especially if they see the value of their use in class. They can alter the content they teach, even if it is mandated by the state department of education, if they believe that the topic and content will be in the in the students' best interest. They also have limited freedom, drawn from their isolation as solo practitioners, to ignore and modify these directives.
>
> (Cuban, 1990, p. 11)

Cuban (1990) acknowledges that teachers do not have total autonomy, however he suggests that teachers are in a position to choose the extent to which a reform is implemented into their classroom. Consequently the role of the teacher is exceptionally important in the implementation of strategies designed to promote an improvement in the teaching and learning of science. Without teachers' support, the implementation of any innovation will experience little or no success (Barnett & Hodson, 2001; Hall & Hord, 1987). Consequently teachers must draw on all their skills, beliefs and knowledge, to facilitate the necessary change, which will lead to an improvement of the quality of teaching and learning of science.

The following sections examine the areas of **teachers' beliefs**, **teachers' workplace demands**, **teachers as life long learners** and **teachers' pedagogical content knowledge**.

Teachers' Beliefs

> the beliefs teachers hold influence their perceptions and judgments, which, in turn, affect their behaviour in the classroom, or that understanding the belief structure of teachers and teacher candidates is essential to improving their professional preparation and teaching practices.
>
> (Pajares, 1992, p. 307)

It has become accepted by researchers that teachers' beliefs are very influential and can have a considerable impact on teachers' classroom practice (Fang, 1996; Pajares, 1992). Fang (1996) determined that teachers theories and beliefs represent the rich store of general knowledge of objects, people and teacher relationships that influence their planning, their decisions and their classroom behaviour. Teachers hold implicit theories about the students they teach, their school subjects and their responsibilities as educators, in fact many researchers have argued that teachers' beliefs act as a filter through which all instructional decisions inside and out of the classroom are based (Fang, 1996). Pajares (1992), however, determined that teachers do not validate their beliefs or test them for their appropriateness, in fact it has been determined that individual beliefs are often not internally consistent within the belief system. Unlike knowledge that can be critically examined and evaluated, beliefs are often unchanging, inconsistent and inflexible, however, they are still seen as the best predictors of teachers' behaviour (Pajares, 1992).

In their *Theory of Reasoned Action*, Ajzen and Fishbein (1980) organised peoples' intentions into two determinants, a person's *attitude towards the behaviour* and the *subjective norm* ie., how other people will view an action taken by the person. Ajzen and Fishbein (1980) reasoned that before a person will commit to a behaviour, he/she must have a positive attitude towards the outcomes of performing the behaviour (*attitude towards behaviour*) and they must feel that people important to them approve of the performance of the behaviour (*subjective norm*). The strength of these two determinants in contributing to the person performing the behaviour depends on a number of external variables, including demographics, social role, intelligence and others. As this theory bridges a number of behavioural domains, different external variables need to be recognised and evaluated depending on the domain. Underpinning these intentions to perform a specific behaviour are beliefs, which have been determined as the best indicators of people's decisions. Evolving from the original *Theory of Reasoned Action* is the *Theory of Planned Behaviour* where three sets of beliefs have been identified, which influences behaviour. These are; attitudes towards the behaviour (ABd), which refers to the beliefs about the consequences of performing a behaviour and evaluation of these consequences; subjective norm (SNd) is the measure of other peoples opinion of the behaviour and; perceived behavioural control (PBCd) which looks at the how easy the behaviour will be and what external factors influence the performance. Research has shown that teacher attitudes to the predictors listed above provide the best indicators that explain teacher intent and consequently predict teachers behaviours (Ajzen & Fishbein, 1980; Cuban, 1990; Lumpe, Haney, & Czerniak, 1998a, 1998b). Other researchers have used repertory grids (Munby, 1984) or case studies (Cronin-Jones, 1991) to determine teachers' beliefs and determine how they influence teachers' actions.

Teachers' views and beliefs become paramount in determining the success or failure of innovations (Cronin-Jones, 1991; Hashweh, 1996; Lumpe et al., 1998b; Munby, 1984). Researchers have determined that teachers do not implement innovations into their classrooms in the way researchers have designed them (Munby, 1984). Munby (1984) describes this phenomenon as the difference in the worlds of the researcher and the teacher. Teachers interpret the innovation's aims based on their viewpoint and ideologies, not those of the curriculum developers; consequently the teacher may not 'see' the major objectives embedded in the materials. Teachers often adapt curricula to fit their knowledge priorities and classroom settings, and influence the learning by choosing material that they see as most relevant to the students (Cronin-Jones, 1991).

Cronin-Jones (1991) has identified four categories of teacher beliefs that influence the implementation of curriculum, these include how students learn, a teachers' role in the classroom, the ability levels of the students in a particular age group, and the relative importance of the content topics. Cronin-Jones's research (1991) determined that teachers often held views incongruent with the discovery-constructivist innovation that they were seeking to adopt. Research by Munby (1982) and Hashweh, (1996) supported this notion with many teachers visualising themselves as behaviour managers within teacher-centred classrooms. Later research by Lumpe, Haney and Czerniak (1998b) revealed that while teachers supported new constructivist innovations, they were hampered by concerns including student management problems, time and resource issues. Byran (1998) demonstrated that it was possible for teachers to hold dualistic beliefs about the nature of teaching and learning, often reflecting both a traditional and a more interactive approach. Keys (2003) refined this supposition that teachers could hold more than one set of beliefs. He proposed that teachers often hold three sets of beliefs; expressed beliefs that are verbalised but not acted upon; manifested beliefs; and entrenched beliefs which form the foundation of teachers' practice (Keys, 2003). Keys (2003) determined that teachers' expressed beliefs were often very different from the entrenched beliefs underpinning their classroom practice.

It can be clearly seen that the curriculum developer must consider very carefully the beliefs and attitudes of teachers to the innovation and their more general attitudes and beliefs to teaching and learning. If teachers' belief structures are incongruent with the underlying philosophy of the intended curriculum then implementation will be severely restricted. Researchers need to put more energy into determining and considering existing teacher belief structures before developing new curricula (Cronin-Jones, 1991). There is the need for professional development to 'target ...specific salient beliefs that appear to influence their intentions and actions in order to foster positive beliefs about teaching...' (Lumpe et al., 1998b p. 18)

Teachers' Workplace Demands

Teachers have been described as "a dilemma manager" and even as "a broker of contradictory interests" (Fang, 1996, p. 51), spending most of their classroom time trying to reconcile opposing ideologies and create a classroom conducive to effective learning. Some of these opposing ideologies have been identified as; promoting equality versus excellence, curriculum based on students' interests versus curriculum based on subject matter, fostering independence and creativity versus setting limits and defining classroom expectations, whether to foster students as 'learners' or 'knowers', whether to adopt a skills-based approach or a process-orientated approach to learning, and to promote subject-based information or foster more generalised skills and information. Fang (1996) identified a number of constraints including, teacher-student interactions, classroom management and routine, the diversity of learning abilities within the class, individual teacher's agendas, resources, school environment and the current educational state and federal climate. He reported that these constraints form an integral part of the school environment and consequently determined that "teachers' theoretical beliefs are situational and are transferred into instructional practices only in relation to the complexities of the classroom" (Fang, 1996, p. 51).

Research has indicated that teachers' working conditions do not just impede teachers from converting their teaching beliefs to practice, it impacts on teachers' self-confidence, motivation and enthusiasm to be committed and dedicated teachers (Louis & Smith, 1990). Louis and Smith (1990) have identified that teachers' professionalism and the factors impacting on quality of working life, together influence teachers' work life and career conditions. Many teachers perceive that they have a poor working life with little or no opportunities for career promotion. They face uncertain conditions with constant debate about the curriculum, pedagogy and academic goals, and classes with a wide variety of student abilities and behaviours. Teachers also perceive a lack of resources and little or no respect and support from the community, these feelings impact negatively on teachers' performance and consequently on teaching and learning in the classroom (Goodrum et al., 2001; Louis & Smith, 1990). Louis and Smith (1990) have identified seven important factors that impact on teachers' quality of work-life. The factors include: respect from relevant adults including their peers, administrators and school staff, parents and the wider community; participation in decision making to empower teachers by including them in decision making and implementation; frequent opportunities for professional interactions; professional feedback on teachers' performance; teachers being adequately skilled with suitable knowledge; resources to teach; and, matching of teachers personal goals with those of the school and the wider school system.

Addressing the factors that have been identified as influencing teachers' quality of work-life, has been determined as essential in improving teachers' work conditions. An improvement in teachers' working conditions will result in a removal of some of the impediments that prevent teachers' from converting their teaching beliefs into practice, however, teachers' work place conditions are complex and variable and remain an important influence on teachers' performance.

Teachers as Life Long Learners

It has readily been acknowledged that schools are places for students' to learn, however there is now a view that schools should also be places for teachers to learn (Guskey & Huberman, 1995). It has been determined that if instructional opportunities for students are to improve then teachers must teach differently. Then, in order for these changes to be significant and worthwhile, "teachers must not only learn new subject matter and new instructional techniques; they must alter their beliefs and conceptions of practice, their 'theories of action'. In order to be successful, therefore, workplace reform should also proceed from our understanding of how teachers learn and change" (Smylie, 1995, p. 93).

Adult learning is based on the same premises that exist in student learning that the learner must be responsible for the learning that takes place and consequently must feel ownership of the learning. Adult learning like student learning must be based within the constructivist framework. In this case a conflict must occur or be created, which must then be resolved in order for learning to occur. The resolution process involves a restructuring of the newly gained information to incorporate the new and prior conceptions. It is also assumed that teachers bring with them to learning experiences a vast array of beliefs and prior knowledge, in a similar way to students. Symlie (1995) also proposes that adults can learn in a number of ways; formally in planned activities; informally due to self-directing exercises; incidentally and accidentally through everyday activities often involving collegial instances. He notes that teachers can be life-long learners and that most of their adult learning is in response to a problem occurring in some portion of their life. Finally, it is believed that, like students, adults must be active and self-directed in their search for solutions to their problems.

There are many adult-learning theories available to explain why and how adults learn as a response to a perceived problem. In one theory considered here, the social learning theory, the learner in this case the teacher, develops knowledge, skills and strategies by watching and interacting with others. This learning can occur by the teachers' direct interaction and learning from these actions, or learning can occur through the actions of others. It is proposed that two constructs effect this process; these are outcome expectations and self-efficacy. Outcomes expectations measure the beliefs about the relationship between actions and consequences (in a similar way to the measuring of beliefs in aspects of the theory of planned behaviour (Cuban, 1990; Lumpe et al., 1998b) and self-efficacy defines a teacher's perceived ability to reach the desired outcome. Teachers' with high self-efficacy will attempt tasks, which are more complex and challenging tasks than learners experiencing low self-efficacy. In the school, the environment can be changed in order to change the outcomes expectations and self-efficacy of the learner. Teachers can be given many opportunities to see others demonstrate new strategies and they themselves can measure the outcomes. When teachers reach specific goals in the change process positive feedback and rewards can raise self-efficacy. These goals must be carefully placed and challenging but attainable in order to increase self-efficacy to the highest achievable level. Other sources suggest that a positive and supportive environment will also help promote the learning process. A less autocratic and more egalitarian and collegial approach will enable more innovative thinking by teachers, and consequently lead to more conceptual learning and change.

Other adult learning theories including the incidental learning theory and organisational socialisation theory, explain how learning can occur in an accidental, unplanned way. The learning capacities essential to the incidental learning theory are pro-activity, critical reflection and creativity. The learner must first identify and then solve the problem, then reflect to discover the underlying assumptions and finally to be able to look beyond and create a new perspective and a new course of action (Smylie, 1995).

All of these theories indicate that innovation and reform, flourish best in an open democratic environment where teachers are encouraged to experiment, and are provided with a sense of empowerment. Teachers are supported to openly reflect with colleagues on their practice, and they need to feel that they can integrate work and learning, and seek external sources to extend their learning experience. School bodies with input from the teachers need to set clearly defined goals both for the organisation and the teachers (Guskey & Huberman, 1995).

Teachers need to be encouraged to be life-long learners and see the school setting as a learning environment not just for the students but also for themselves (Guskey & Huberman, 1995). They need to scaffold a framework with clearly defined goals and rewards (ie. promotions, certification) for their career as teachers and learners (National Research Council, 1996). Teachers will then feel enthused and excited to try new learning strategies and skills to help students to be engaged and supported in their classroom learning.

Teachers' Pedagogical Content Knowledge

It has been determined that effective and innovative teachers often employ the same teaching strategies as less effective teachers (Fang, 1996; Loucks-Horsley et al., 1998). The question to be asked then is what do these successful teachers do in order to be more effective, or what do these teachers know that directs and informs their actions? Based on a review of a large number of studies Brophy and Good (1986) concluded that "effective instruction involves selecting (from a large repertoire) and orchestrating those teaching behaviors that are appropriate to the context and the teachers' goals, rather than mastering and applying a few 'generic' teaching skills" (p. 360). This critical knowledge for effective teaching has been called teachers' pedagogical content knowledge or PCK. Pedagogical content knowledge is described as the "transformation of several types of knowledge for teaching (including subject matter knowledge), and that as such it represents a unique domain of teacher knowledge" (Magnusson, Krajcik, & Borko, 1999, p. 95). Teachers use their pedagogical content knowledge to transform subject matter knowledge, amalgamating it with the appropriate teaching strategy to produce a strategy that is contextually and content appropriate.

Pedagogical content knowledge includes; knowledge of the content of their discipline; knowledge of the students that they teach; their understanding of the forms of assessment and learning strategies involved; and of the larger context in which they teach (Fang, 1996; Loucks-Horsley et al., 1998). As part of teachers PCK is the deep understanding of how some concepts in science are more difficult than others and needs different strategies to explain them to students. These strategies may need to be modified or postponed until the student is more conceptually able.

Facilitating Teacher Change

Researchers have determined that change to teachers' practice is a process that is complex, and takes time and persistence, the idea that change can happen as a result of a single workshop or a few weeks of a new science program is unrealistic. Most systems are resistant to major change, although systems are continuously refined to improve their effectiveness. Change efforts are more effective when the purpose of the change to be made is clearly articulated and meticulously planned and supported (Kotter, 1995; Loucks-Horsley et al., 1998). Although researchers perceive the need for a system change, they have already noted that it is the teacher's skills and abilities, which determine the effectiveness of the change. Individual change through each teacher is the mechanism by which a complete system change can be accomplished (Guskey & Huberman, 1995).

Hackling et al. (1999a) reflected

> If secondary science teachers, who have been trained to teach traditional science in traditional ways, are to accommodate to the new classroom practices required by the curriculum frameworks and syllabuses they must undergo significant personal and professional change (p. 4).

This section seeks to examine the most effective mechanisms to achieve those outcomes identified by Hackling et al., (1999). It examines; **the strategies necessary to create**

effective professional learning innovations, and the purpose of the components of **the CASSP (Collaborative Australian Secondary Science Program) model.**

Strategies Necessary to Create Effective Professional Learning Innovations

> As professionals, teachers realise that their learning about teaching does not stop when they are credentialed. Rather, they expect to continue learning throughout their teaching career and to be able to improve their practice significantly with appropriate professional development learning opportunities.
>
> (Loucks-Horsley et al., 1998, p. 32)

As Loucks-Horsley et al. (1998) describe, teachers are on a learning journey set to continue throughout their professional lives. As professionals, it is teachers themselves who are responsible for identifying and implementing changes to their practice, consequently, any change innovation must be designed to respond to the needs and the concerns of the teachers (Fullan, 1995).

It has become clear over the last several decades that professional development innovations are an important instrument in fostering teachers' continued development as life-long learners (Guskey & Huberman, 1995; Smylie, 1995). The mechanisms of facilitating teacher professional learning have changed considerably over the past years. Previously, professional learning experiences were called professional development and were normally single day 'hit and run' type seminars organised and directed by facilitators outside of the school. These were organised without in-put from the teachers, ie. 'in-service' PD prevalent in the 1970s involved bringing in outside 'experts' to instruct teachers in new teaching strategies. Teachers' concerns and ideas were not considered relevant or useful.

More frequently in recent times it has been acknowledged that the term professional development or PD has become too restrictive to encompass the modern professional learning innovations. The CASSP (Collaborative Australian Secondary Science Program) encompasses a number of components including a professional development component.

It has now been determined, however, that designing a professional learning innovation is a very complex process with many different factors that influence its development

(Guskey & Huberman, 1995). Loucks-Horsley et al. (1998) designed a process/framework, which provides a scaffold on which to plan and create change innovations. The framework starts by setting goals and then proposing a plan, which is translated into action and is consequently followed by reflection (Reason & Bradbury, 1994). At the early goal setting and planning stages, however, there are many variables to consider. These include; the knowledge base of the professional learning innovation developer and of the teachers; the various change innovation strategies that the developer has at his/her disposal; the context in which the framework is placed, which include classroom issues, organisational constraints, the support of the principal and the school administration; and any critical issues within science that the developer must consider (Bolman & Deal, 1992). The key to this framework for designing a professional learning innovation to promote teacher change is continual reflection and feedback. Reflection and feedback help the developer modify and shape the innovation, as it is being designed and implemented.

Effective change innovation has been thoroughly researched and consequently many attributes of effective professional learning programs have been identified. These attributes share many similarities with the attributes identified as necessary for improved student learning. These attributes include; ability of teachers to work collaboratively and collegially; an understanding of teachers' prior knowledge; promotion of experimentation and risk taking; provide time for teachers to reflect on their learning experiences, and to seek further clarification where necessary; allow teachers to be involved in all aspects of the PD; supply appropriate rewards to encourage teacher participation; and provide links to the department, the school, the wider organisation and provide other PD opportunities (Guskey & Huberman, 1995; Loucks-Horsley et al., 1998). These attributes correspond with the necessary features of the adult learning theories, which promote the best learning system for teachers (Smylie, 1995).

Loucks-Horsley et al. (1998) have reviewed the available research and synthesised a common vision of effective teacher professional learning.

Their framework of effective professional learning innovations is based on seven principles:

1) have a clear, well-defined purpose of what it is aspiring to achieve;
2) allow teachers opportunities to build on their knowledge and skills;
3) model with examples the strategies to be taken to the classroom and used by the teachers;
4) be part of the continuous development of the learning community;
5) provide opportunities for teachers to lead reform efforts;
6) help provide links to other parts of the education system; and,
7) consistently review its success in meeting its objectives and ensuring a positive impact on teachers' effectiveness and students learning and attitude.

Other research has identified further factors to be considered in influencing the success of a change innovation include the influence of a teachers peer teachers and the support of the principal and administration (Bolman & Deal, 1992; Hall & Hord, 1987; Louis & Smith, 1990). Doyle (1979; 1983) determined that students were important stakeholders in the change process and had a vested influence in proposed changes to the science classroom. He determined that students were often reluctant to support changes to teachers' practice, which would result in changes to their learning. Doyle (1983) and Entwistle (1981) determined that some students, particularly highly successful ones had developed their style of learning to suit the traditional teaching style occurring in their classroom. Their learning is mainly surface, rote-learning of a large number of remembered isolated facts and these students are motivated more by the desire to gain good grades and tertiary entrance rather than to develop deep understanding (Ames, 1990; Entwistle, 1981). In this scenario, students are focused on the classroom nuances, knowing what information to attend to and the exact nature of the assessment items. The strategies underpinning the CASSP program seek to promote deep, comprehensive learning motivating students by engaging them in student-centred, inquiry-orientated studies of relevant science. Doyle (1983) notes that if students are not supportive of the changes proposed in the classroom they are capable of exerting considerable sway over the teacher. In some cases students are able to persuade the teacher to return to a more traditional teaching style and away from strategies that have been identified as best practice (Doyle, 1983).

Although there is a large amount of research on what constitutes effective change innovation, recent research in Australia by Invagarson and Loughran (1997) has indicated that change innovations in Australia over the past few decades have not had a clear purpose. It has been suggested that until now, there have been no aims or expectations for teacher professional learning innovations and consequently they have been largely irrelevant to teachers, who have had no incentive to participate. In fact they has been described as being imposed rather than owned by teachers, lacking credibility, non-sustainable, brief and as a one-off event rather than as part of long-term sustainable and effective program (Guskey & Huberman, 1995). Teachers from Ingvarson and Loughran's study (1997) mostly worked in complete isolation of other members of the department and consequently had no method of interacting collaboratively and gaining new teaching strategies to improve their teaching and learning.

Change innovations are being designed with a new direction and purpose in improving teaching and learning. As seen earlier in this review, the present situation in teaching has been reviewed and exposed, and strategies for improving teaching and learning have been articulated. Using the fundamentals of effective teaching practice and the framework developed by Loucks-Horley et al. (1998) a teacher professional learning model has been developed, the Collaborative Australian Secondary Science Program (CASSP) model, to promote teacher change.

Collaborative Australian Secondary Science Program (CASSP): A model for facilitating teacher change

This model was developed to support and guide teachers in their efforts towards attaining excellence in their teaching practice. It is based on the supposition that teachers are professionals who are responsible for implementing and adapting innovations to improve student learning in their classrooms (Cuban, 1990; Goodrum et al., 2001).

The Collaborative Australian Secondary Science Program (CASSP) was designed to cultivate, and where necessary strengthens teachers' practice. Hackling et al. (1999a) reported

> Teachers' understanding of the new pedagogies and classroom practice and their use of them in teaching, learning and assessment will be developed through professional development, participative inquiry and exemplified through concrete examples in a curriculum resource (p. 4).

The model integrates three components; professional development, curriculum resources, and participative inquiry (Figure 2.1). These approaches are known to be effective individually in promoting teacher change in schools, but there is little evidence that all three elements have been integrated into one model. The States' and Territories' science curriculum officers, the Australian Academy of Science, Australian Science Teachers Association, and the Curriculum Corporation all supported the implementation of this model.

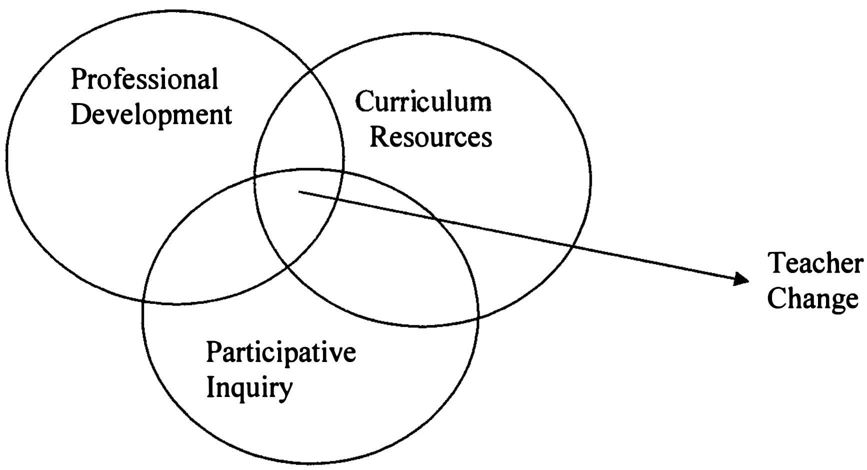

Figure 2.1. The relationship between the three components of the CASSP model (Hackling et al., 1999)

Curriculum resources

The curriculum resources have been developed not as a set of highly structured lessons, but a set of resources from which the teacher is able to select material appropriate to the learning needs of the students. Embedded in the curriculum material were many of the strategies designed to improve student learning. These strategies included; eliciting students' prior knowledge, contextualising the learning into students' everyday experiences to increase the meaningfulness of the tasks and their understanding of the world around them; providing students with opportunities to undertake investigations and problem-solving tasks, encouraging group work to promote social interactions. Assessment resources supported the implementation of diagnostic and formative assessment, and summative assessment focused on outcomes that contribute to scientific literacy.

Participative inquiry

The term 'participative inquiry' was refined by Reason and Bradbury (1994) to promote a new direction in classroom research. The purpose of this research was three-fold; it served to produce knowledge and actions that were specifically useful to a group of people, empowering the participants to construct their own meaning through their experiences and to gain a true commitment to a democratic and collaborative association in the process. Traditionally educational research had only been considered valid and reliable, when it was controlled by the researcher from outside the classroom, maintaining an objective distance between researcher and subject. In participative inquiry, teachers were being encouraged to perform research in the classroom, collaboratively with their peers and outside researchers (Reason & Bradbury, 2001; Watts et al., 1997). In this type of research teachers/participants are important in the setting of the agenda for the research and are influential in collecting the data.

> Participative research values the subjects' knowledge and sharpens their capacity to conduct their own research in their own interest, helps them appropriate knowledge produced by the dominant knowledge industry for their own interests and purposes ...... liberates their minds for critical reflection, questioning and the continual pursuit of inquiry.
>
> (Reason & Bradbury, 1994, p. 329)

This form of research is interested in the reality of the subject and their input is very valuable. Reason and Bradbury (1994) determined that participants in this form of research can become empowered and consequently make significant changes to their world. They state that it is only through experience can subjects and researchers reach understanding. Communication forms the key to successful participative research, with collaborative meetings important in helping to identify the key issues of the research, to improve the sense of community, to reflect on the progress being made and to continue the momentum of the research. Either qualitative and/or quantitative data collection techniques can be used to collect data in participative research (Reason & Bradbury, 1994).

The focus of the participative inquiry component of the CASSP model is three-fold; firstly in encouraging teachers to reflect on and review their own classroom practice and how this influences student learning; secondly, to promote collegiality between science teachers within a department and, thirdly to support teachers collaborating to evaluate, the effectiveness of the new strategies embedded in the curriculum material and to brainstorm solutions to any problems that arise.

Professional development

As previously discussed, professional development is an extremely important factor in promoting change. Professional development needs to be ongoing if it is to promote sustainable change, rather than a single isolated event. Professional development in the CASSP model was designed to be prolonged and sustained and give teachers the opportunity to reflect on the ideas presented and return at a later date to ask questions and review concepts (Goodrum et al., 2001; Loucks-Horsley et al., 1998).

The professional development incorporated a number of facets including; examining teachers' beliefs about effective teaching practices and assessment, providing participating teachers with help to plan, implement and assess an exemplary unit on Energy, discussion of contemporary constructivist teaching methods; and developing a range of strategies to promote inquiry-based, student-centred, co-operative learning resulting in more scientifically literate students. Subsequent professional development sessions allowed teachers opportunities to direct the sessions through the articulation of their concerns.

Monitoring the Impact of Professional Learning Programs

This final section examines a number of existing **models of change** and then examines the **Concerns-Based Approach Model** (Hall & Hord, 1987) and the version modified by Dlamini, Rollnick and Bradley (2001). These models have been chosen to monitor and analyse teachers' experiences as they participate in the CASSP program.

Models of Change

The use of models to monitor individual change has been used in a range of professions. In the health domain, a popular model for examining change is the transtheoretical model (Prochaska, Norcross, & DiClemente, 1994). This model incorporates insight from a variety of disciplines within health, and identifies six stages of change. These stages are precontemplation, contemplation, preparation, action, maintenance and termination. The model incorporates descriptors and behaviours that can be used to highlight progression of the patient through the model (not always linear continual movement). Prochaska, Norcross and DiClemente's research found that some patients changed as they were in the action stage of the model, however, they found that patients who were in the earlier more reflective stages, precontemplative and contemplative, were not ready for action and although thought about changing, did not change. They found that in a population undergoing a program to encourage giving up smoking; over 50% of the population were in these early stages of the change process even after experiencing the program and consequently did not change. They point out that many programs were considered failures if a large percentage of the population did not change after being involved in the program. This may be due to the level of readiness of the individual for the program. They consider that people in different stages of the change process need different input to enable them to move forward. Prochaska, Norcross and DiClemente's (1994) transtheoretical model uses the process of decisional balance, a weighing-up of the pros and cons of changing before the person will commit to change. While the cons outweigh the pros, the person will not consider changing, however, after interventions and through time the balance may shift, if it does, the person will be closer to initiating the change behaviour. Although this model is very useful in the health domain, it does not add the dimension of patient understanding to the model in the way Hord and Hall's (1987) Stages of Concern model does.

The Concerns-Based Adoption Model (CBAM) of Change

The Concerns-Based Adoption Model (CBAM) focuses on the teacher and measures their perceptions of the change process. It seeks to understand the practices of teachers and their concerns about changing. The model attempts to emphasise "understanding teacher attitudes and skills so that support activities such as staff development, coaching, provision of materials and so on, can be directly related to what teachers perceive they need" (Hall & Hord, 1987, p. 5).

The model is based on a number of underpinning assumptions regarding the change process. The primary assumption is the importance of the teacher and their concerns in the change process, as without a solid understanding of the experiences and background of the teachers the change process will be impeded. As mentioned previously, implementing a change into a school and/or a classroom is not an event but a long-term process. It is unrealistic to expect the change will be implemented immediately and completely, it may take weeks, months and even years before such a change is complete. Too many innovations have been disregarded as unsuccessful because researchers have not allowed a sufficient timeframe for the change (Hall & Hord, 1987; Loucks-Horsley et al., 1998). Hall and Hord (1987) also postulate that they can predict much of what is going to happen throughout the change innovation and consequently plan and implement strategies to keep the process on task. They stipulate that time should be spent gathering information on who is using or not using the innovation and why. This allows corrections to be made to the implementation process. Other assumptions include the need to spend as much time and energy on implementing the innovation as developing it.

The CBAM model uses three dimensions to monitor the individual teacher's progress through the change process. These are Stages of Concern (SoC), Levels of Use (LoU) and Innovation Configurations (IC). Using probes and interviews, change facilitators can observe and measure these three areas and consequently guide the change process and report on how it is affecting teachers.

The first diagnostic tool available to researchers is the *Stages of Concern*. This is a measure of the concerns that the teacher is experiencing as they progress through the innovation. How teachers feel and perceive the change will determine whether or not the change actually occurs in the classroom. It is very important, therefore, for researchers to be able to map the differing perceptions and concerns that teachers have. Teachers have concerns through out their teaching careers, and these number and type of concerns vary, as they become more experienced educators. Research has determined that teachers start their careers with *unrelated concerns*, which are not related to teaching at all. Then they move on to *self-concerns*, which are egocentric and express feelings of doubt in their own performance. When teachers become more experienced their concerns become more *task orientated* relating to schedules, materials and timetables. Finally teachers become concerned about the impact of their teaching on their students and their lives, these concerns are known as *impact concerns*.

Hall and Hord (1987) found that teachers undergoing a change process also expressed concerns in a similar fashion to those they experienced in their beginning years. Hall and Hord (1987) have identified seven stages of concern, through which teachers travel as they move through a change experience. It is important to note that teachers do not necessarily move in a linear progression through the change process, they can move in any way and need not visit all the stages. The seven stages are:

Stage 0 Awareness – this is an unrelated concern. Teachers have few concerns about the innovation and no involvement.

Stage 1 Informational – this is a self-concern. Teacher seeks information about the innovation without any thought to impact on teacher. Few concerns are raised.

Stage 2 Personal – this is a self–concern. Teachers concerns are about the requirements/demands of the innovation and their abilities to meet these demands. The advantages and disadvantages of the innovation are considered and the potential impact on the teacher lives.

Stage 3 Management – this is a task concern. Teachers attend to the actually working demands of the innovation and the logistics of running the innovation.

Stage 4 Consequences - this is an impact concern. Teachers are focused on the impact of the innovation on his/her students. Teachers determine the relevance of the innovation and how changes need to be made in order to adopt it more effectively

Stage 5 Collaboration – this is an impact concern. Teachers are focused on the cooperation and collaboration of their peers.

Stage 6 Refocusing – this is also an impact concern. Teachers look to a wider application of the innovation including extending and expanding the innovation (Hall & Hord, 1987).

Research has demonstrated that there is a predictable pattern that occurs in the frequency and intensity of concerns and this can be displayed on a profile. Assessing these concerns and determining the intensity of those concerns, can be carried out using, a questionnaire or an interview. It has been determined by prior use of the concerns theory that concerns change over time in an fairly predictable manner (Hall & Hord, 1987). Using fluctuating levels in teachers' concerns, facilitators can make predictions about the success of the innovation. Where necessary design strategies can be introduced to redirect the change process.

The second diagnostics tool that Hall and Hord. (1987) devised was the *Levels of Use* (LoU). This tool moves away from teachers' thoughts and feeling to look at the teachers' behaviour. Again there is a pattern in the behaviours displayed as teachers progress through the innovation, which can be studied and predictions can be made. Hall and Hord (1987) identify eight levels in their *Levels of Use* profile; three behaviours describe non-users and the other five, users. *Non-use* is the first level and a person at this level is not involved in the innovation, and has very little knowledge of it. At the *orientation* level, the teacher is starting to seek out information about the innovation. In the *preparation* stage, the teacher is preparing to use the innovation. When the teacher first starts to use the innovation, the teacher is only interested in the day-to-day use of the innovation, and 'getting by'. This first level of use is known as *mechanical use*. The second level of use is *routine*, where teachers have stabilised their usage of the innovation, however, they made few adjustments or changes to their pedagogy. The third level of use is *refinement*, where the teacher is able to use the innovation more confidently and is interested in the impact on the student. The next level of use is *integration*, where at this level the teacher is able to make changes to and combine this innovation with input from their colleagues. Finally teachers can reach a *renewal* stage of use, whereby teachers can re-evaluate the innovation and synthesis and adapt the innovation into totally different situations. Teachers are most confident in their use of the innovation at this level. It is often the case that teachers do not progress past the mechanical stage of use in this model. Dlamini et al. (2001) have adapted Hall and Hord's *Level of Use* to produce the *Typology of Use* which is set out in five levels.

Dropouts –The teachers did not continue to use strategies from the innovation after the primary attempt. Consequently these teachers are non-users.

Strugglers – These teachers continued to use the innovation but at a very mechanical level, without making any changes or adaptations, and with a low level of understanding.

Domesticators – Teachers in this group are able to see the difference between their old way of teaching and the strategies in the innovation. These teachers, however, incorporate the new strategies into their normal teaching approach.

Succeeders – These teachers are able to use the innovation successfully but are not able to be totally independent of the materials.

Innovators – These teachers understand the innovation and are able to vary and generalise the innovation to other areas of their teaching.

Dlamini et al. (2001) combined the data on the *Level of Use* of the innovation with profiles of teachers' understanding of the innovation. The five stage hierarchy of teachers' understanding of the innovation incorporate the following stages.

Unawareness - Teachers do not perceive the difference between their previous approach to teaching and the new approaches in the innovation.
Perception - Teachers are aware that the new approach is different from their old method of teaching, however, they fail to demonstrate further understanding.
Utilisation - Teachers are able to describe the new innovation articulately and give examples of lessons, which contain aspects of the innovation.
Personalisation - Teachers are able to personalise the approaches specified in the innovation and adapt the strategies to other lessons. Teachers at this level are able to continue using these strategies after the completion of the unit.
Production – Teachers reaching this, the highest level of understanding are able to develop their own lessons and take ownership of the innovation.

Dlamini et al. (2001) noted that teachers who demonstrated an understanding of the innovation were able to use the innovation at a high level.

Dlamini et al. (2001) developed these typologies to map the changes in teachers exposed to a Science Technology and Society (STS) innovation in South Africa. These profiles were considered suitable to monitor the progress of teachers experiencing the CASSP change model (Goodrum, Hackling, & Deshon, 2000). Researchers can now measure the concerns of the teachers using the Hall and Hord (1987) *Stages of Concern*, their understanding and their levels of use of the innovation using the Dlamini et al. typologies, which in this case is the CASSP model of change (Goodrum et al., 2000).

Summary

A need for change to occur in the teaching and learning of science has been identified by Goodrum, Hackling and Rennie's (2001) report. They proposed a number of approaches to improving the scientific literacy of Australian students. These approaches include; teaching students within a constructivist framework; focusing on investigations and practical work as a way of developing inquiry; contextualising learning to students' everyday life to make it more relevant and interesting to students; using formative assessment to monitor students' individual progress; and promoting the use of information technology within the science class.

Teachers are of vital importance in implementing changes in teaching, learning and assessment and research has shown that without teachers' support innovations can come and go without impact. In order to promote effective change, teachers' needs and beliefs must be considered, and teachers must understand and support the changes that are being promoted. The CASSP teacher change model has been designed to precipitate and support teacher change, using a combination of professional development, participative inquiry and curriculum resources. The CASSP model uses as its underlying premise the notion that teachers have the ability to be life-long learners and need to feel enthusiastic, interested and empowered. CASSP is based on a constructivist framework and encourages teachers to feel a sense of responsibility and ownership of the changes that are being implemented. The model seeks to foster a constructivist supportive environment during the scheduled professional development days, which it is hoped will continue to envelop the teachers once they return to their classrooms. The participative inquiry component seeks to embrace a sense of reflection on performance by teachers, promote collegiality among peers and provide opportunities for the construction of new professional knowledge. The curriculum materials have embedded in them components of all the dimensions demonstrated as essential in improving teaching, learning and assessment

In order to measure the impact of the CASSP teacher change model on the four case study teachers, Hall and Hord's concerns-based model (Hall & Hord, 1987) as adapted by Dlamini, Rollnick and Bradley (2001) have been used to determine teachers concerns, their levels of use and understanding of the model. The study also examines the contextual workplace factors that impinge on the implementation of the innovation, and student's perceptions and attitudes pertaining to the teaching and learning subsequent to the implementation of the CASSP model.

CHAPTER 3: METHODOLOGY

Introduction

The study describes and analyses the implementation of the CASSP program and determines how the intervention; impacts on teachers' classroom practice and on teachers' understanding of the strategies embedded in the program; effects teachers' beliefs and attitudes about teaching, learning and assessment; increases students' enjoyment of and engagement in learning science; and, provides opportunities for collaborative peer reflection. The study used semi-structured interviews, observations, student surveys and teacher questionnaires, to develop an in depth understanding of teachers' practice.

This Chapter is divided into eight sections, which identify and discuss methodological aspects of the study. Section one, **context** provides the background of the study. Section two, **research design** outlines the framework on which the study is constructed examining the qualitative and quantitative approaches that have been used. Section three, the **Researcher** details the background of the Researcher and provides an insight into her beliefs about science teaching. Section four considers the **population and sample** of teachers and schools chosen to be part of the study. Section five, **procedure**, reviews the methods of data collection and the ethical issues of collecting data in a school. The **instrumentation** developed for the study and their limitations are examined in section six. Section seven focuses on the **data analysis**, and the culminating section, section eight, outlines the **limitations of the study**.

Context

Time Table for the Full Development of CASSP

The CASSP professional learning program was developed in three stages. This study contributed to the evaluation of the second stage.

CASSP stage 1 – The initial program trial in WA in 2001

The initial trial in 2001 involved five schools in Western Australia. Science staff gathered at the start of term two for the initial two-day professional development, and the unit materials were made available to them. They returned to their classrooms and engaged in teaching and learning from the supplied curriculum resources, attending a second professional development session in week five (half way through the unit) and the final professional development at week 10 (the end of the unit). They also attended regular participative inquiry sessions within their science department, throughout the term for reflection and discussion. Data gathered from the teachers and students during this study were used to modify components of the professional development and curriculum materials before stage two.

CASSP stage 2 – The national pilot conducted Australia wide, term two 2002

The national pilot was a study of 28 schools across six States of Australia. This pilot had two purposes, the first purpose was to establish national collaboration between all the States and Territories demonstrating that the jurisdictions could work together to develop curriculum and PD resources for use in all of the States and Territories. The States and Territories have traditionally developed their own material in isolation meaning that professional development designed for one State has limited viability in other States. This led to a duplication in efforts which is wasteful. The second purpose was to determine if the CASSP model was effective in supporting teacher professional learning in a larger group of teachers throughout Australia (Goodrum et al., 2003).

CASSP stage 3 – Full implementation of CASSP

The third stage, is projected to be a full implementation of the CASSP program providing professional learning and curriculum resources for teachers of Year 8-10 science, and is dependant on the approval of the Federal Government and the necessary funds being available. Research findings from Stage 2 will be used to refine the CASSP model and the design of the professional development, curriculum and participative inquiry resources.

CASSP Stage 2: The CASSP National Pilot, Term 2, 2002

The focus of CASSP Stage 2 was the implementation of student-centred, inquiry-based constructivist strategies into lower secondary science classrooms. The teachers were encouraged to integrate these strategies into their classroom practice, and it was hoped that this would lead to the development of more independent learners who were interested and motivated.

The CASSP professional learning model incorporates three major components; professional development workshops, curriculum resources, and participative inquiry.

The CASSP Program incorporated three and a half days of professional development (PD) throughout the duration of the trial. These face-to-face workshop sessions were constructed at the beginning, middle and end of the program. The pedagogy of PD sessions was designed so that the teaching strategies used with the participating teachers emulated the CASSP strategies embodied in the Energy unit for the students. The initial two day professional development component of CASSP in phase I of this study (Table 3.2) was designed to help teachers to: reflect on current teaching practices; discuss contemporary constructivist teaching methods; develop a range of strategies to promote inquiry-based, student-centred, co-operative learning resulting in more scientifically literate students. The second professional development session during phase II of this study (Table 3.2) allowed teachers time to participate in collegial discussions with the other teachers in the Program, encouraging them to reflect on the effectiveness of new teaching strategies, resolve problems and exchange ideas with their peers. CASSP researchers answered teachers' questions about aspects of assessment and levelling and other areas of concern. The final half-day of professional development in phase III of this study (Table 3.2) provided opportunities for teachers to reflect on their experiences, discuss their project experiences and the future of the Program and allowed the researchers to collect further data.

The curriculum resources were developed for a 10-week Year 9 Energy unit as the basis of their curriculum resources. In addition to providing opportunities for students to develop the *Energy and Change* outcomes of the new science framework, the unit also contained many of the processes, skills and attitudes from the *Working Scientifically* strand embedded in it (Hackling, 1998; Hackling et al., 1999a). The curriculum resources comprised a set of resources for the teachers and a separate activity book for students. The materials in the student resource book provided students with a number of learning activities set amid real life experiences, assessment items, and discussion questions to guide the students' learning. The student resources were very visual in appearance and were available in both print and electronic form. The strategies embodied in the resources promoted learning for understanding rather than rote memorising of facts, encouraging the use of groups to facilitate student collaboration and interaction. The materials also incorporated diagnostic and formative assessment to allow teachers to determine prior understanding and how students were progressing through the unit. The teachers' resource book gave teachers additional notes and directions to help them choose activities that matched their students' abilities. The intellectual demand of activities was indicated using a star rating system from the easiest level represented by a single star, up to the hardest level which corresponded to a three star rating. In addition, the teachers' resources contained a summary of the major CASSP strategies, and an explanation of the role of participative inquiry (PI) in the program including a list of questions to guide the PI discussions.

The CASSP model promoted collegial review and reflection on classroom practice in the form of participative inquiry (Reason & Bradbury, 2001). A number of participative inquiry (PI) discussions were encouraged throughout the 10-week program at which all the teachers involved in the innovation within the school met to discuss, reflect on and work together to solve emerging problems. Focus questions were provided to help structure the PI discussions which were run in most cases by the Head of Science Department or an appointed Program Coordinator (Hackling et al., 1999a).

Research Design

The study is based within a social constructivist epistemology and an interpretivist paradigm. The study sought to engage with teachers in their natural environment so as to better understand the complexity of the factors that influence their practice. As Denzin and Lincoln (2000) states there is a need to "study things in their natural setting, attempting to make sense of, or interpret phenomena in terms of the meaning people bring to them" (p. 2). The study incorporates two distinct research strategies, case studies which are grounded within the qualitative domain and surveys which are quantitative in nature.

Yin (2003) defines a case study as a strategy which "investigates a contemporary phenomenon within its real-life context, especially when the boundaries between context and phenomenon are not clearly evident (Yin, 2003, p. 13). Yin (2003) went on to argue that the case study is an important research strategy that uses input from many sources, including primary and secondary documents, observation and subject interviews and is therefore ideal to examine all the complex interrelating factors that influence the classroom teacher involved in the teaching and learning process. Cohen and Manion (1996) recognised a number of advantages to using case studies including; being easier and more interesting to read than other strategies; based in a real life setting which often relate to the reader's own experiences; and, capturing and expressing the often contradictory nature of the subject and their experiences. Yin (2003) argues that data triangulation, which involves different data sources (i.e. observation and interviews) all seeking to answer the same research questions, is an important mechanism for corroborating findings regarding a particular phenomena. This triangulation, however, increases the cost involved both in monetary and time costs.

It was only possible to conduct case studies on a small number of teachers, therefore, survey research was used to monitor the experiences of other teachers participating in the trial. The survey data provides complementary information about whether other teachers' experiences of the Program were the same as the case study teachers. The survey data were collected in the form of three questionnaires completed by all the WA teachers forming the sample for this study, and a single survey post innovation completed by students of the case study teachers of this study. In order to determine the substantive generalisability of the questionnaire data, the following must be considered;

- the respondents must understand the questions,
- respondents interpreted the questions as intended,
- respondents must be eager to respond,
- respondents must be honest in their answers,
- respondents had knowledge to respond, and,
- responses must be recorded, interpreted and coded accurately (Jaeger, 1988).

These questionnaire data and the case study observations and interviews provided a rich description of;

- teachers' beliefs and attitudes about their science teaching practice,
- teachers' experiences over the 10-week CASSP program,
- teachers' relationships with their peers and the extent to which they work collaboratively, and,
- students' engagement with and enjoyment of school science.

The case study data produced a detailed picture of the teachers' experiences over the 10-week program. The data was collected from teachers and students participating in the study by questionnaires, surveys, interviews, discussion groups and observations. The Researcher acted as a non participative observer of the natural setting of the lower secondary science classrooms (Cohen & Manion, 1996).

Within the interpretivist paradigm the characteristics of data and claims that are most pertinent to the social constructivist epistemology are plausibility, trustworthiness, credibility and authenticity. It is important to realise that these terms are social judgements and are therefore based within current social context. Smith and Deemer (2000) conjecture that the terms plausibility and credibility are the key elements of validity in qualitative research. They explain the claim is plausible if it can be accepted on face value given the reader's existing knowledge. If the reader decides that the claim is not plausible, they must make a judgement on the credibility of the claim (J. Smith & Deemer, 2000).

Researcher

This qualitative study was interpretive in nature. The Researcher drew on her experiences and understandings of secondary science teaching and learning to interpret and construct meaning from the comments made by teachers and students, and her observations of classroom events.

The Researcher has a Bachelor of Science degree, a Graduate Diploma of Education, a research-based Master of Education and has seven years teaching experience. The Researcher has taught a wide variety of science-related subjects in a number of schools, these include lower secondary science, electronics, chemistry, biology, human biology, senior science and primary science. She has taught in several state schools in a variety of socioeconomic areas as well as a small Anglican independent school and a large independent Anglican girl's school.

The Researcher believes that teachers are facilitators of learning, providing opportunities and situations to help students actively understand and make sense of the world around them. She believes that learning should be contextualised to increase its relevance to students and that students should acquire from their science education a wide variety of skills and processes. The Researcher also believes that all students are capable of achieving some degree of scientific literacy and all students should enjoy and be engaged by science education.

Population and Sample

The National Pilot study involved 122 teachers from 28 schools from six states around Australia. These schools were self-selected, they had responded to an invitation to participate in the National Pilot issued by the researchers (Goodrum et al., 2003).

This Ph.D. study was limited to WA participants, 25 teachers from six schools in Western Australia. Originally there were 25 teachers in this study, however, two of the teachers who attended the first PD were replaced by other teachers during the term due to timetable changes within the school. Two other teachers were unable to attend the second PD due to other school commitments and one of these teachers was also unable to attend the final PD. Consequently these four teachers were not included in the final sample so the results were based on 21 WA teachers.

All the schools and teachers participated in the survey research. Two WA schools, one Independent school and one State school, and their teachers formed the focus of the case study component of the research. Two teachers from each school were selected to be case-study teachers. The schools were assigned letters to protect their identity, A and B.

The four case study teachers were chosen where possible to provide a sample of teachers with a variety of ages, gender, and experience in science teaching and level of qualification to give a diverse and richer perspective to the data collection. The time-tabling of the Year 9 science classes, however, was a significant factor when choosing the case study teachers as the Researcher needed to be able to observe the lessons taught by these teachers. The Researcher attempted to attend all the lessons, however, this was not always possible and an Observation Diary (Appendix 3.2) was used to record all of the lessons attended. Over the course of 10 week term the Researcher observed, recorded and coded a total of 89 lessons.

The students who participated in the student survey were members of the Year 9 classes of the four case study teachers who were part of the WA trial. To gain greater insight into the experiences of the students a small number of students (17 students in total) were chosen at random to participate in student focus group discussions with the Researcher.

Case Study Teachers

A description of the teachers participating in the case study component of the study is provided in Table 3.1. The case study teachers were assigned pseudonyms to protect their identity, Ann and Amy taught at independent School A and Bob and Beth taught at state School B. Three of the teachers in the case study were female. The teachers' classroom experience varied between 5 and 25 years. All of the case study teachers were biology or human biology specialists.

Table 3.1. Description of the teachers participating in the case study

Teachers' pseudonyms	School	Qualification	Experience
Ann, female	Private girls school	B Sc. Ed	Biology major with 25 years experience
Amy, female	Private girls school	Diploma of Teaching*	Human Biology major with 13 years experience
Bob, male	Government school	B.Sc. Dip Ed.	Biology major with five years experience
Beth, female	Government school	B Sc. Ed	Biology major with five years experience

*The Diploma of Teaching is a three-year pre-service teacher education award

Procedure

The CASSP Program was implemented in term three of 2002. Schools participating in the study had already been identified prior to the trial and their science teachers briefed on the expectations and framework of the Program. At the first PD day, teachers were advised of the research data collection component of the program.

From this larger group of teachers, four teachers were invited to be involved in the case study component. These teachers were briefed by the Researcher on the details of the study and the level of teacher involvement required. Teachers' commitment and interest in participating in the study ensured the Researcher was a welcome observer to the classroom activities and an unobtrusive observer of staff room interactions at school participative inquiry sessions. Over time, the Researcher and teachers developed a positive rapport and it seemed that the teachers were comfortable with the nature and purpose of the study. Written consent was sought and obtained from every teacher participating in the study, and parental and student consent was sought from every student the Researcher interviewed.

In Table 3.2 the time table of the CASSP program is described on the left hand side of the page and how the three phases of the research component of the study relate to the program are illustrated on the right hand side.

Table 3.2. Research procedures and data analysis

CASSP Program		**Study Procedure**
Term 2 Teachers in study participated in *initial PD* and received Curriculum Resources.		*Phase I Study – before teachers experience innovation* **Teacher Questionnaire I** - elicited teacher's beliefs and concerns **Teacher Interview I** – examined case study teachers' beliefs and concerns in detail
Term 3 Teachers taught Energy Topic using *Curriculum Resources* and strategies provided by CASSP project. Mid Topic – *Mid term PD* addressed existing concerns End Topic – *Final PD*, addressed final concerns and provided time for reflection.	***Teachers encouraged to participate in Participative Inquiry session once per fortnight***	*Phase II Study – during innovation* **Classroom Observations** of case study teachers throughout the term– determined teachers' use of innovation and student attitudes **Teacher Questionnaire II** - elicited teachers' concerns and understanding **Teacher Interview II** – elicited case study teachers' concerns and understanding of CASSP strategies **Participative Inquiry** – attended teachers' participative inquiry sessions at case study teacher schools and determined further details of teachers concerns and understanding of innovation *Phase III Study – at the end of innovation* **Teacher Questionnaire III** - reviewed teachers' practice and concerns **Teacher Interview III**– reviewed case study teacher practice seeking to highlight their concerns and understanding **Student Survey** – elicited students' attitudes to science topic **Student Focus Group Discussion** – interviewed students from case study teachers' classes to determine attitudes to the science topic.
Term 4		

Phase I of the Study

The Researcher administered the first teacher questionnaire (Appendix 3.1) to the entire group of teachers at the first professional development session, the questionnaires were all collected by the Researcher ensuring a 100% return rate.

The first semi-structured interviews with the four case study teachers were also carried out before the commencement of the teaching program. All interviews were tape recorded and subsequently transcribed and coded by the Researcher.

Phase II of the Study

The Researcher sought to attend every Year 9 Energy lesson taught by the four case study teachers, and all lessons attended were logged in the Lesson Observation Diary (Appendix 3.2). The observational data were recorded using a specially designed Observation Sheet (Appendix 3.3). The Researcher sought to identify the teachers' understanding of the CASSP strategies, their success in implementing the innovation, and the students' level of engagement with and enjoyment of the science lessons. After introducing herself and the trial briefly in the first lesson, the Researcher sat as unobtrusively as possible at the rear of the classrooms, and did not participate in the lessons.

In week five and six, the Researcher interviewed each of the four case study teachers to elicit a more detailed picture of their beliefs about, concerns with and understanding of the innovation.

During the trial the Researcher sought to attend all the formal PI sessions at each case study school (A and B). This enabled the Researcher to examine how well the teachers collaborated together, and to identify any concerns and/or successes experienced by the participating teachers.

Phase III of the Study

At the conclusion of the Energy topic, which coincided with the end of term, students from all of the participating WA teachers' classes completed an in-class student survey administered by their teachers. This thesis considered only data from the students in the classes of the four case-study teachers.

Additionally the Researcher interviewed students from each case-study teachers' class in focus group discussions. These discussions involved groups of three or four students who participated in a taped interview, commenting on their experiences in the science class during the Energy unit.

All the WA teachers were required to complete a further questionnaire (Appendix 3.1, Questionnaire 3) regarding teachers' practice, concerns and understanding and the four case study teachers were again interviewed using semi-structured interviews and their responses were tape-recorded, transcribed and coded.

Phase IV of the Study

It was initially intended that there would be a phase IV to this study, which would have involved interviews with case study teachers teaching the Year 9 Energy topic in the following year. Unfortunately none of the four teachers were scheduled to subsequently teach Year 9 science.

Instrumentation

This section is divided into two sections the first, examines instruments and protocols used in this study. The second section seeks to determine within the context of this study, how trustworthy each instrument and protocol is and what factors needed to be considered when using that instrument or protocol.

Instruments and Protocols

A variety of instruments were developed to collect data from the teachers participating in the study. These included

- teacher questionnaires (Appendix 3.1),
- teacher interview protocols,
- classroom observation protocol (Appendix 3.3),
- participative inquiry observation protocol,
- the student survey (Appendix 3.4), and
- student focus group discussion protocol.

Teacher questionnaires

All three questionnaires were designed to identify the main clusters of teacher concerns, attitudes and beliefs about lower secondary science teaching and learning. The questionnaires elicited information from teachers in the study, about: their beliefs and attitudes about teaching and learning; their classroom practices which they consider to be most effective; the concerns that teachers have about teaching and learning; and their understanding of the underpinning philosophy of the CASSP model. All questionnaires included a range of questions including open-ended, ordinal and numerical scale questions to elicit data from the participating teachers.

Phase I questionnaire elicited

- the teachers' experience, qualifications, areas of expertise and perceived strengths in teaching lower secondary science,
- teachers' beliefs and concerns about science teaching and learning,
- a picture of the teachers' current practices specifically in the Year 9 classroom, and
- what teachers hoped to achieve from participating in the program.

(Appendix 3.1, Questionnaire 1)

Phase II & III questionnaires elicited details regarding

- the effectiveness of the curriculum materials and professional development sessions,
- the most and least successful aspects of the unit as judged by the teachers and,
- a review of teaching practice, any changes in teaching practice and how these changes impacted on students.

(Appendix 3.1, Questionnaires 2 and 3)

These questionnaires also contained a number of questions examining teachers' concerns and ideas about incorporating outcomes-based assessment into the Energy unit.

Table 3.3. Foci of instruments and protocols

Data instruments	Research questions	Sample size	Subjects	Teacher beliefs	Teacher concerns	Teacher under-standing	Strategy success	Student attitude	Factors Impact change
Phase I. Before Innovation									
Teacher Questionnaire I	1, 2	21	WA teachers	X	X				X
Teacher Interview	1, 2, 3,	4	Case study teachers	X	X	X			X
Phase II. During Innovation									
Teacher Questionnaire II	1,2,	21	WA teachers		X				X
Teacher Interview	2, 3, 6	4	Case study teachers		X	X			X
Classroom Observation	4, 5, 6,	89 lessons	Case study teachers and students				X	X	X
PI Observation	1,2, 3, 4	5- 8	Teachers at school A and B in PI			X	X		X
Phase III. Post Innovation									
Teacher Questionnaire III	1, 2, 4	21	WA teachers	X	X				X
Teacher Interview	2, 3, 6	4	Case study teachers	X	X	X			X
Student focus discussions	5, 5	16	Selected students from case study classes					X	
Student surveys	5, 5	100 (approx.)	Students from case study classes					X	

Table 3.4. Classification of interview questions

Teacher Interview	Focus Area	Research questions	Details
Interview 1	Experience		Please provide a thumbnail sketch of your teaching career up to this point
			Why did you choose teaching?
	Beliefs	1	What is the purpose of teaching science to lower secondary school students? What are the most important things for students to learn?
	Ideal science	1	What do you think really good teaching and learning looks like? What does the teacher do? What do the students do?
	Actual science	1,2	If you had to describe your classroom experiences with you LSS classes in a couple of key words, what would they be? Can you elaborate?
	Concerns	1,2, 6	What aspects of the teaching process concern you? In your own classroom?
		2,3	A number of innovations are planned for secondary science. What changes are planned at your school? How do you think these changes will impact your teaching?
Interview 2	Classroom practice	3,4, 6	How is your teaching going this term? Have there been any changes to your teaching practice since being involved in this project?
	Concerns	2, 3, 4, 6	What, if any are your concerns about teaching your Year 9 science class? Are there any concerns with any aspects of the new program?
	Curriculum resources (CR)	2, 3, 4, 6	What aspects of the CR have been the most and least useful to you? Are there any sections you did not use or used in a different way?
	Professional development (PD)	2, 3, 4, 6	What aspects of the initial 2-day PD were most and least useful to you? Do you agree with all the proposed strategies?
	Participative Inquiry (PI)	2, 3, 4	Describe your experiences with the PI sessions. What do you feel they have achieved for you? Did the other staff seem keen to participate?

Interview	Focus Area	Question	Details
3	Classroom practice	1, 2, 3, 4, 6	Do you think this project has been successful in helping you improve the quality of science teaching and learning? How?
		2, 3, 4	Are there any CASSP strategies or approaches that you will incorporate in next terms Year 9 science classes? Please give examples.
	Curriculum resources (CR)	2, 3, 4	What are your overall comments on the CR resources provided for this unit? Would you use them again next year? Why?
	Professional development (PD)	2, 3, 4, 6	How useful was the mid term PD? What aspects were useful? What aspects would you change?
	Participative inquiry (PI)	2, 3, 4	Did you feel you benefited from the PI sessions? How could they be improved?
		4, 6	Do you think your science department would continue with the PI sessions?
	Concerns	2, 3, 4, 6	Are there any aspects of the new teaching strategies that concerns you?

Teacher interviews

The four teachers in the case study group were interviewed about their beliefs regarding teaching, learning and assessment. These interviews provided the Researcher with a rich detailed description of the teachers' thoughts and feelings about teaching and specifically about the strategies incorporated in the CASSP materials. The interviews were based on protocols designed by Dlamini, et al. (2001). These researchers developed open-ended interviews to determine teachers' understanding of the innovation they implemented, and these interviews have been adapted to be used in this study. These semi-structured interviews focused on determining what the teacher understood about the underpinning ideas of the CASSP innovation and how they were able to interpret their understanding to promote student learning in the classroom. The questions were designed to elicit truthful answers from teachers, and consequently care was taken to ensure the teachers felt relaxed and comfortable.

Phase I interview

The initial interview focused on teachers' concerns and beliefs about their current teaching practice, and sought to determine if teachers had any prior knowledge of the elements of effective teaching and learning.

Phase II interview

The second mid-innovation interview focused on the teachers' concerns on the impact of the strategies embedded in the CASSP innovation on teaching and learning. It asked teachers to illustrate how they implemented the core strategies and approaches from the innovation, and whether they consider these strategies had any impact on students' learning.

Phase III interview

The post-innovation interview focused on teachers' concerns about their teaching practice and the implementation of the strategies and approaches promoted in the CASSP model. The interview sought to determine the extent to which teachers understood the strategies and approaches embedded within the Program.

Classroom observation

The Researcher used classroom observations to determine the success and extent of the innovation's implementation and subsequent effect on students' engagement and enjoyment. An observation sheet (Appendix 3.2) was developed to collect information on the type and nature of the lesson, the students' engagement level, and the strategies utilised by the teacher. The Researcher recorded information on the type of lesson taught, the level of engagement of the students, the contextual setting, the use of questioning and assessment, and the type of investigation/inquiry utilised and if the lesson challenged the students. It also provided space for the Researcher to record which section of the curriculum material the observed teacher is referring to in each observed lesson. These findings enabled the Researcher to determine how successful the observed teacher was in implementing the strategies and approaches embedded in the CASSP materials, and the level of engagement and interest of the students.

The Researcher observed a total of 89 lessons approximately 70 % of the lessons taught by each of the four case study teachers over the 10 weeks of the Energy unit, the dates and times were recorded in the lesson observation diary (Appendix 3.3)

Observation of participative inquiry discussions

The science teachers in all the participating schools were asked to discuss a number of prepared focus questions relating to aspects of the innovation, during the trial. These questions were designed to encourage a climate of frank and open discussion about classroom practices at their school. This collaborative reflection provided opportunities for teachers to articulate their perceptions of the success of the strategies they were using in the classroom, and the students' level of interest and enthusiasm. The Researcher attempted to observe all the participative inquiry (PI) discussions at Schools A and B. The Researcher recorded each session and also recorded such information as: time of the discussion, the date, which staff attended; any major themes or ideas discussed; and, the perceived level of collegiality and collaboration between staff in dealing with issues and resolving problems. The PI sessions also provided additional insights into teachers' understanding of the innovation and the teachers' success in using the strategies to improve teaching, learning and assessment.

Student survey

The Year 9 Energy students of all case study teachers were surveyed at the end of the trial, to determine their experiences and feelings towards the Energy unit. The student survey consisted of a series of four questions. Students answered the question by choosing a face, which represented their feelings about that question, either, a happy, neutral or sad face (Appendix 3.4). Each question also included a bubble space allowing students' space to write a few lines to explain the face they selected. To maintain students' interest, the survey was very short and was drawn in a cartoon form, it was completed in class and collected by the Researcher ensuring a very high rate of return. The survey was validated using the students of the teachers participating in the initial WA trial in 2000.

Student focus group discussion

Four or five self-selecting students from each case study teachers' class were asked a number of questions about the type of science they have been experiencing in the classroom to try to determine if they found it interesting and engaging.

Focus questions included:

- Has this terms science been useful and interesting to you?
- What is your reaction to the Energy unit?
- What activities, experiments, and investigations did you enjoy most?
- What activities, experiments, and investigations did you enjoy the least?
- What, if anything have you learnt in this unit? What would be an example?
- Was the teaching and learning in this unit different in any way from your previous work in science?

The casual group discussion setting created an environment where students felt more relaxed and comfortable, and the responses were compared to the data collected from the student surveys and provided elaboration to the more limited details produced by the survey as well as information triangulation.

Trustworthiness of the Instruments

The research was designed to ensure the results would be considered trustworthy and reliable. Original teacher questionnaires had already been tested on a small group of teachers during the initial WA CASSP trial in 2000. The Researcher adapted these questionnaires to address the research questions for this study set out in Chapter 1. Further piloting of these questionnaires was carried out in term one to determine the relevance of the questions for eliciting the information required and to ensure there are no ambiguous or leading questions.

The student survey to determine students' attitudes was also extensively piloted in Stage I of CASSP during 2001. The Researcher administered and collected the student survey in the case study teachers' classes. This reduced the possible interference of the teacher in influencing student responses and ensuring students' privacy.

In the collecting of classroom observations there is always an interaction between subject and observer. In the classroom the presence of an outsider initially caused intense interest from the students and impacted on the behaviour of the teacher. Over the course of the trial, however, the Researcher became a regular observer of the classes and very quickly the classroom returned to normal as the teacher and students became used to the presence of the Researcher. The Researcher tried to take this interaction into account when interpreting more subjective data and triangulated and substantiated it with other data in order to validate the observations (Guba & Lincoln, 1981) i.e. teacher and students questionnaires.

This interaction between Researcher and teachers also occurred in the PI sessions and during the teachers' interviews. It has been reported that interviews are powerful means of eliciting information from a subject, especially in a face-to-face format. The interviewer (the Researcher) sought to elicit information by attaining a balanced rapport with the teacher, by being casual and friendly while being focused and impersonal in order to be an 'interested listener' without passing judgment on the subjects' responses. The interviewer sought to be flexible and make changes to interview style depending on the circumstances of the interview (Fontana & Frey, 1994). Semi-structured interviews were designed to increase the interviewer's understanding, however, unlike unstructured interviews which are about general understanding, semi-structured sought to determine a greater understanding about a specific concept or set of related concepts.

A group discussion is defined as "the systematic questioning of several individuals simultaneously in formal or informal setting" (Fontana & Frey, 1994, p. 364). In this type of interview the interviewer directs the interaction in either a very formal or informal structure to gather information. In a similar way to one-on-one interviews the Researcher must be flexible, objective, empathetic, persuasive and a good listener. A group interviewer, however, must have extended skills. These skills include preventing an individual or group from dominating; encouraging reluctant subjects to participate; and ensuring all members of the discussion group respond to each question. In short when interviewing the Researcher sought to act as moderator gathering honest and insightful information (Fontana & Frey, 1994). Advantages of this sort of interview type are that they are data rich, inexpensive, flexible, interesting to participants and allow individuals to remind and aid each other's memories.

Data Analysis

Data gathered through naturalistic inquiry cannot be reduced to a fixed number of discrete variables rather "they are intricately interrelated to form a pattern of 'truths'. It is these patterns that must be searched out, less for the sake of prediction and more for the sake of *verstehen* or understanding" (Guba & Lincoln, 1981, p. 57).

Teacher Questionnaires

There were three types of questions incorporated into the questionnaires including; open ended category type questions where the Researcher constructed a series of categories based on teachers' responses and summarised the numbers of answers in each category; there were ratings type questions where teachers were asked to rate a process/approach using a number scale (ie. 1 poor – 5 very good); and finally, there were simple questions where teachers were required to indicate the answers with an appropriate mark, (ie. a tick). The data were recorded first in Excel spreadsheets and then imported into to the SPSS statistical data processing computer program and later recorded in the tables seen in Chapter 4. A portion of questionnaire one's coding manual is included in Appendix 3.5.

Teachers' Interviews

After transcribing the interviews verbatim, the Researcher sought to identify the level of teachers' understanding of the ideas and strategies embedded in the CASSP resources.

The Researcher sought to develop a story of the teachers' experiences during the CASSP trial. These stories are told in results Chapters 5 and 6.

Common themes were identified from the interviews and classroom observations of each teacher, which were coded and recorded. Using data gathered from the interviews and subsequently the classroom and participative inquiry observation, the teachers were grouped according to the criteria identified by Hall and Hord (1987) into levels of concerns and Dlamini et al. (2001) into levels of understanding and utilisation of strategies. Data were reported in a case study format and illustrated with quotes from the teachers' classes, interviews and PI sessions and from the students in their classes.

The data collected in the questionnaires was compared with the case study observations and interviews allowing for the triangulation of the information increasing its credibility and trustworthiness.

Student Survey

The student survey sought to determine the students' engagement and interest in the unit, by examining the mean rating of survey items or percent of positive responses. In open response questions the reoccurrence of common themes was identified and their frequency noted.

Student Focus Group Discussion

The student group discussions were transcribed verbatim and subsequently the Researcher sought to identify and categories any common themes and beliefs. The data collected in the interviews was compared and with the data collected by the student surveys, allowing a richer depth of information to be collected, to allow a further source of data to triangulate the results.

Classroom Observations

The classroom observation instrument and any extra field notes taken by the Researcher were analysed to identify the extent that teachers utilised the curriculum materials and from their actions how well teachers understood the strategies they were using. The set of identifying criteria that teachers demonstrate when reaching a level of understanding (Dlamini et al., 2001) was used as a comparison for the data collected in this study.

Teachers have been placed in a category according to the characteristics they exhibit in classroom observations and in interviews. A similar set of criteria has been identified to indicate the level of success that teachers have reached in using an innovation. Using classroom observations the Researcher sought to group the teachers into levels of understanding and utilisation, and subsequently develop a typology for the four teachers in the study (Dlamini et al., 2001; Hall & Hord, 1987).

Participative Inquiry Observations

The dialogue from the PI discussions was transcribed verbatim and themes identified and extracted. This information was also used to determine the level of teachers' understanding and success of use of the innovation, and secondly to identify any concerns the teachers were experiencing and to examine the collegial relationship that existed between teachers within a science department.

Limitations of the Study

There are several factors limiting the usefulness of a study that utilises this design and data collection methods. These factors include the relevance of the questions used in the questionnaires and surveys, in providing the Researcher with details of the teachers' beliefs and concerns. In order to determine the 'right' questions to ask to secure the information required, a piloting of the questionnaire and surveys was carried out. In this case the teacher questionnaire and the student survey were piloted in the study of WA teachers who trialled the CASSP model in term two of 2001. Further refining of the teacher questionnaire occurred for this study and the refined model was piloted in the first part of term one of 2002 on three teachers who did not participate in subsequent trials.

Another factor that could have limited the effectiveness of the study is the honesty of the participants of the study. It is very easy for questionnaire respondents to answer questions in the way they think the questions should be answered, rather than in a totally honest way. It is possible that some teachers give answers that they think would portray them in the best light. In order to encourage teachers to be frank and honest, the Researcher tried to create an atmosphere of trust and confidentiality.

The sample size of the study was another limiting factor that must be considered. There were only 25 teachers in WA participating in the CASSP trial and subsequently only 21 of these teachers completed all the questionnaires. The wider CASSP study included a further 95 teachers from around Australian, who completed the same questionnaires. In the final analysis there was a mortality rate and consequently only 21 teachers from WA were involved for the entire study, and only a further 68 from the larger Australian sample.

Only four teachers were examined in depth, as part of the case study component, and this provided a vast quantity of data on each individual teacher. The study, however, refrained from making generalisations beyond the data for the WA teachers.

The self-selection of the schools participating in the study may also have created another limiting factor by imposing a potential bias on the schools.

Summary

Generalisations are assertions that are context free and it is very difficult to find any situation in education as it relates to "human behaviour that is not heavily mediated by the context in which it occurs" (Guba & Lincoln, 1981, p. 62). This study, however, does not seek to formulate generalisations and consequently predict human behaviour. It provides a 'window' into the experiences of a small group of four teachers as they experience the CASSP teacher change model.

The study collected data in the form of;

- teacher questionnaires to seek details on teachers concerns and beliefs about their teaching and learning practices and the introduced concepts of the CASSP model;
- student surveys to determine information about the students experiences in the science classroom where CASSP strategies were implemented.
- teacher interviews to determine how well teachers understood what they were teaching, and to gauge their concerns and beliefs about their teaching practice;
- student interviews that expand and elaborate on data collected in the student surveys about the interest and perceived relevancy of science; and
- classroom and PI observation to determine teachers' understanding of the CASSP model strategies and establish teachers' success in implementing these strategies.

Data was gathered during the implementation of the Energy unit, in term three of 2002. Phase I of this study included the first teacher questionnaire and interviews. Phase II of this study occurred over the 10 weeks in the middle of the unit, when the Researcher observed classroom lessons, attended participative inquiry sessions and re interviewed the teachers, and teachers completed a second questionnaire. Phases III of this study at the end of the unit, at approximately week 10, included teachers completing a third questionnaire and the case study teachers were interviewed for the third time. Student surveys were also carried out at this time in conjunction with a limited number of student group discussions.

CHAPTER 4: TEACHER QUESTIONNAIRE RESULTS

Introduction

This Chapter examines the results from the teachers' questionnaires, which were used to gather information about teachers' professed beliefs about teaching and learning generally and the specific concepts underpinning the innovation. The teachers completed questionnaires before they participated in the innovation, during the innovation and after the innovation.

This Chapter maps and examines teachers' initial position, their experiences throughout the innovation and their positions at the conclusion of the CASSP project. The first section, **context**, provides contextual information about the schools and teachers who participated in the CASSP study. The second section, **teachers' professed beliefs**, examines the professed beliefs about teaching, learning and assessment that the teachers bring to the trial. It seeks to determine teachers' ideas about best teaching practice and any conflict arising between this ideal and teachers' beliefs about their actual practice. The third section seeks to follow the **teachers' journey through the innovation**, examining their changing concerns regarding the different aspects of the CASSP model, curriculum resource, professional development, participative inquiry and their impact on teaching and learning. Section four, **impact on teachers' professional learning**, examines teachers' perception of the benefits and whether the program should be continued on a wider scale.

The final section, **impact on students**, considers teachers' opinions about students' enthusiasm for science and engagement with the new CASSP strategies and whether they think the program has improved students' learning.

Context

This section outlines the timeline for the program the schools which participated in the WA trial, and demographic data about the teachers who participated in the study.

Timeline

The CASSP project started with the first of three professional development (PD) sessions, in the last week of Term Two, July 1st and 2nd 2002. After the teachers arrived on the first day of the PD session, the teachers signed letters of informed consent for the research and then they completed Questionnaire One. Teachers commenced teaching from the CASSP resources on 22nd July, the start of Term Three and concluded at 10 weeks later on the 27th September. The second professional development session was a single day on Tuesday 27th August at the beginning of week six of the trial, and Questionnaire Two was completed at the commencement of this session. The final professional development was an afternoon session on Thursday 26th September at the end of the final week of the trial, and Questionnaire Three was completed on this occasion.

Schools

Six Western Australian schools participated in the trial. These included one semi-rural K-10 district high school, one fee-paying independent Anglican school for girls (Yr. K-12), and four state senior high schools (Yr. 8-12) in the Perth metropolitan area. The number of teachers sent from each school depended on the size of the school and consequently the number of teachers teaching Year 9 science. Table 4.1 shows the distribution of the teachers from the WA schools involved in the CASSP trial.

Schools were also asked to nominate and send a program co-ordinator to all of the professional development sessions. The role of the co-ordinator was to facilitate the participative inquiry in the school, and provide support for the teachers at that school participating in the trial. In many cases, but not in all, the nominated program co-ordinator was the Head of the Science Department, and a number of the program co-ordinators also taught Year 9 students.

Table 4.1 The number of teachers from each school participating in the CASSP trial

Schools participating in the trial	Number of teachers
School 1	1
School 2	5
School 3	4
School 4	4
School 5	6
School 6	1
Total	21

Teachers

Twenty-five teachers commenced the CASSP trial, however, only 21 attended all of the professional development sessions and completed all three questionnaires. The data presented in this Chapter is based on the 21 teachers who completed all three questionnaires.

There were almost equal numbers of male and female teachers who participated in the WA CASSP trial. Eighty percent of the teachers had degrees which incorporated both science and education. Only one teacher had a postgraduate qualification. The teachers did, however, have a wide range of experience as shown in Table 4.2 below. It is interesting to note that many of the teachers had either less than five years experience (43%) or more than 20 years experience (33.5%).

Table 4.2. Years of teaching experience for the CASSP trial teachers (n=21)

Number of years teaching experience	Frequency	Percent
1 year or less	1	5
1-2 years	4	19
3-5 years	4	19
6-10 years	2	9.5
11-15 years	2	9.5
16-20 years	1	5
21-25 years	2	9.5
26-30 years	1	5
Above 31 years	4	19
Total	21	100

The questionnaire also sought to determine the teachers' area of teaching speciality. Table 4.3 shows that 10% of the teachers in the trial were not primarily science-trained teachers and 57% of the teachers had a biological area of speciality. Interestingly 67% of the teachers participating in the trial did not have a physical science background even though the unit in the trial involved teaching the physical science topic, Energy.

Table 4.3. Area of teaching specialty (n=21)

Area of teaching speciality	Frequency	Percent
Physical science	7	33
Biological science	12	57
Other, non-science	2	10
Total	21	100

Explanation of the Tables

In the tables above, Tables 4.1, 4.2, and 4.3 the total number of respondents is 21, the total number of teachers participating in the study. In some of the tables in the remainder of the chapter, however, the total for the analysed data is not expressed as the number of respondents but as the number of responses. For the open-ended questions many teachers gave more than one answer to a particular question. The percentages refer to the percentage of responses in a particular category compared with the total number of responses for that question.

Teachers' Expressed Beliefs

Questionnaire One elicited the teachers' expressed beliefs regarding the purpose of lower school science, the characteristics of effective teachers and learners, and asked teachers to describe what is actually occurring in their classrooms. When teachers were asked what the purpose of teaching lower school science was, there were a large number of varied replies as seen in Table 4.4 below.

Table 4.4 Teachers' responses to the question: What do you believe is the main purpose of teaching lower secondary science? (n=21)

Response category	Frequency	Percentage
Helping students to use science to interpret their world and make considered decisions	12	24
Develop an interest in science and foster an inquiring mind	9	18
Develop an interest in general science principles	7	14
Foster in students a love and an enjoyment of science	7	14
Develop skills and science processes	6	12
Prepares students for post-compulsory education	5	10
Enable students to relate their classroom science to real life experiences	1	2
Contribute to overall education and personal development of students	2	4
Total	49 [a]	100

[a] There were 49 responses to this question, indicating that some respondents gave more than one answer to the question.

Twenty-four percent of all responses explained that science was a useful interpretative tool, which "enables students to understand more about themselves and their surroundings" (Teacher 10).

Although the responses are varied, 30% of respondents acknowledge that science is integrally linked and connected to students' world and everyday real life. Science should be taught "to add meaning to everyday experiences" (Teacher 16) and as "a way of finding answers to questions, as well as an awareness of how society uses science" (Teacher 21). Teacher 13 noted that it is important to "educate the students about the world around them and getting them to ask 'why' and 'how' questions about their world".

Teachers were also asked to list the attributes of an effective science teacher, Table 4.5 summarises the teachers professed beliefs about effective teaching. Of the 56 responses to this question, there were no more than nine responses or 16% in any category, showing that the teachers had different ideas about the characteristics of effective teaching.

Table 4.5. Teachers' responses to the question: I believe science teaching is most effective when the teacher does the following? (n=21)

Category of responses	Frequency	Percent
Provides a wide variety of motivating activities	9	16
Knowledgeable about topic and student learning strategies	7	13
Chooses tasks and activities that are suited to all students	6	11
Has a good relationship with students	6	11
Provides hands-on experiences	5	9
Relates science to the real world and other topics	4	7
Uses a range of teaching skills effectively	4	7
Other responses	4	7
Marks assessments promptly and gives feedback to students	3	5
Manages a classroom effectively	3	5
Allows independent investigations	2	3.5
Provides opportunities for productive student discussion	2	3.5
Plans lessons effectively	1	2
Total	56	100

Teaching has been acknowledged as being complex and composed of many facets, this may be reflected in the diverse range of activities that the teachers in the trial listed above in Table 4.5 as important attributes contributing to an effective teacher. It may have been very difficult to single out a particular attribute that makes an effective teacher; rather it is the combination of many attributes that creates a well-rounded effective classroom educator.

Table 4.6. Teachers' responses to the question: I believe science learning is most effective when the students do the following. (n=21)

Category of responses	Frequency	Percent
[a] Actively **participates** and behaves in ways that enhance learning	16	25
Engages in discussion in group work and class discussion	9	14.5
[a] **Participates** in a variety of motivating activities	9	14.5
[a] Are **interested** and **enthusiastic** about science	8	13
Respects and trusts the teacher and be willing to take risks	5	8
Takes responsibility for their own learning; reflect on learning	5	8
Other responses	4	6
[a] **Participates** in group work	3	5
Relates science understanding to the real world	2	3
Investigates own choice of topic	1	2
[a] **Participates** in tasks suitable to their abilities	1	2
Total	63	100

When asked to describe effective student learning behaviours, the majority of the attributes listed by the trial teachers can be summed up in a few words; engaged, enthused, interested and participating. In Table 4.6 there is a number of categories, however, the ones marked with an [a] denote those which contain the words listed above and these categories grouped together comprise 73 % of all responses.

Once the first questionnaire had established the respondents' overarching views about effective teaching and learning, the teachers were then asked to consider their practice and what they considered to be best practice. This required respondents to reflect on their practice and to determine how this varied from best practice. It was predicted that marked differences between teachers' actual practice and teachers' views of best practice would create concerns for respondents about teaching and learning in their classrooms.

Firstly, teachers were asked to divide-up the time they spent on different classroom activities (ie. group work, teacher talking etc) in a typical Year 9 science class that term.

They were then asked to compare this with how they imagined they would spend their time in an ideal classroom. From the results in Table 4.7 below, it would seem that the respondents did perceive a difference between what currently occurs in their classroom and how they imagined their ideal class.

Table 4.7. Teachers' responses to question: Consider an ideal lower secondary science lesson and a typical one of your actual science lessons, and determine the relative amount of time spent on the following tasks. (n=20)

Teaching and learning activity	Time allocation			
	Ideal classroom		Actual classroom	
	Percent	Std. Dev	Percent	Std. Dev
Teacher explaining to whole class	10	4	16	9
Whole-class discussion	18	9	12	7
Group based practical and activity work	46	14	37	14
Giving notes to students	8	4	12	7
Students working individually including from the text book	18	10	23	12
Total	100		100	

On the whole, the respondents felt that they spent longer explaining to the class than would be ideal, and less time on class discussions and group practicals then they would like in an ideal classroom situation. A few respondents, however, did think that they had the balance of time allocation "right" in their classroom, with one teacher commenting underneath this question "I guess I think I've got it right" (Teacher 16).

To investigate further, teachers were presented with a number of statements about teaching and learning and asked to decide how frequently this occurred in their own Year 9 classrooms that term, and also in an ideal science class. This information is presented in the two tables below, Table 4.8 demonstrates how frequently these statements relate to the teachers' idea of an ideal classroom and Table 4.9 represents how frequently these behaviours occur in an actual Year 9 science class.

Table 4.8. Percentage of teachers indicating how frequently certain behaviours occur in an ideal Year 9 class. (n=21)

Statements about teaching and learning	Always	Most of time	Some of time	Seldom	Never
	Percentage of respondents				
The major focus is completing unit content	0	62	19	19	0
The unit is organised around contexts and issues relevant to students	23.5	66.5	10	0	0
Students must follow experiment instructions given by the teacher very carefully to reach the correct conclusions	10	5	66.5	13.5	5
Students plan their own experiments to investigate their own questions	19	33	48	0	0
Practical work is used to illustrate the concepts that have been introduced	24	38	38	0	0
Practical work is used to provide experiences of phenomena before concepts are introduced	24	33	43	0	0
Students work in groups for most of their work	10	47.5	42.5	0	0
Skills that enhance the effectiveness of learning in groups are explicitly taught	33	48	14	5	0
Discussion is not encouraged as a quiet class most productive	0	0	19	57	24
Whole class discussion occur at the conclusion of activities with the main ideas summarised	38	33	24	5	0
Assessment is used mainly for grading and reporting	0	42.5	47.5	5	5
Assessment is mainly portfolios and work samples to determine where students are at and where to go next	24	29	42	5	0
The reporting of students' progress is in levels for outcomes	30	30	10	15	15
Students learn science that is relevant to their lives	43	52	5	0	0
Student prior beliefs are considered when planning lessons	48	33	19	0	0
Students have access to computers to research information	38	33	24	5	0

Table 4.9. Percentage of teachers indicating how frequently certain behaviours occur in an actual Year 9 class. (n=21)

Statements about teaching and learning	Percentage of respondents				
	Always	Most of time	Some of time	Seldom	Never
The major focus is completing unit content	5	61	29	5	0
The unit is organised around contexts and issues relevant to students	0	24	71	5	0
Students must follow experiment instructions given by the teacher very carefully to reach the correct conclusions	10	24	52	14	0
Students plan their own experiments to investigate their own questions	5	5	61	24	5
Practical work is used to illustrate the concepts that have been introduced	10	42.5	42.5	5	0
Practical work is used to provide experiences of phenomena before concepts are introduced	5	24	57	14	0
Students work in groups for most of their work	5	38	57	0	0
Skills that enhance the effectiveness of learning in groups are explicitly taught	5	19	57	19	0
Discussion is not encouraged as a quiet class most productive	5	5	29	51	10
Whole class discussion occur at the conclusion of activities with the main ideas summarised	19	38	38	5	0
Assessment is used mainly for grading and reporting	24	38	33	5	0
Assessment is mainly portfolios and work samples to determine where students are at and where to go next	0	14	53	14	19
The reporting of students' progress is in levels for outcomes	10	37.5	5	10	37.5
Students learn science that is relevant to their lives	5	35	60	0	0
Student prior beliefs are considered when planning lessons	5	24	42	24	5
Students have access to computers to research information	5	24	42	24	5

The comparison of Tables 4.8 and 4.9 indicates a number of differences between the ideal and actual classrooms. In an ideal classroom, only 19% of respondents felt the focus would be on finishing the unit content always or most of the time, however, in their actual classrooms, 67% of respondents felt that there was a focus on finishing the unit always or most of the time. In their actual classrooms, the majority of teachers felt under pressure to complete the unit content within the prescribed time frame. In the ideal situations 90% of classes would have science units organised around the relevant content always or most of the time, however, this would always or mostly occur in only 24% respondents' actual classes. In teachers' actual classroom it was reported that 24% of teachers seldom or never let students investigate their own research questions whereas in ideal classroom 0% would seldom or never let students investigate their own research questions. In the ideal classroom, the practical work would precede the explanation of concepts in 57% of the classes compared with only 29% of the respondents' actual classes. When considering students' prior beliefs, 33% of respondent always or mostly considered them in their classroom, however, in their ideal classroom 81% of respondents would consider students' beliefs mostly or always. Respondents saw a big discrepancy in the assessment that was currently carried out in their classroom. Sixty-two percent noted that assessment was for grading and reporting in their classrooms always or most of the time, and only 14% of respondents felt assessment was to plot students progress most of the time or always. In their ideal classroom the assessment would be more balanced with 43% of respondents using assessment for reporting and grading most of the time or always and 53% of respondents ideal assessment would be allocated for plotting students progress most of the time or always. All respondents reported that there would be very little change in their classrooms with regard to group work, which they felt was already completed to an acceptable level. Respondents also felt that students learnt science relevant to their lives the majority of the times in their current classes.

In an actual classroom 62% of respondents think discussion should be discouraged seldom or never, while in the ideal classroom 81% of respondents think discussion should be discouraged seldom or never.

For many areas of teaching and learning respondents reported a difference between what was actually occurring in their classroom and what their ideal scenario would look like. Concerns arise from differences between actual and ideal teaching, learning and assessment. Below in Table 4.10 the respondents' main concerns about their teaching are set out.

Table 4.10. Teachers' response to the question: What, if any are your main concerns about your own teaching? (n=21)

Concerns	Frequency	Percent
Concerns about teaching/learning strategies used	11	24
Other responses	6	13
Student attitude and motivation	5	11
Range of student ability	5	11
Available time for science classes and preparation	5	11
Teachers lack of interest and enthusiasm	3	7
Extra-curricula demands	2	4
Keeping up to date with new IT	2	4
Number of students/ diversity of classes to teach	1	2
Range of students abilities	1	2
Concerns about quality and amount of curriculum	1	2
Changes in curriculum- too many too fast	1	2
Assessment demands	1	2
Lack of experience	1	2
Lack of resources	1	2
Total	46	100

There are 46 responses indicating that respondents had at least one concern about their teaching and many had more than one concern. It can be seen that the major concern for teachers is the effectiveness of the strategies that they are currently using in their science classes. One respondent sought "teaching strategies to cope with the changing times" (Teacher 12) while another realised limitations within their assessment framework commenting it was "not diagnostic enough to pitch it at every child's level" (Teacher 7), and another reported that he "finds it difficult to use 'student-centred learning' all the time" (Teacher 1).

Subsequently teachers were asked to list the major factors, which they considered limited their practice, preventing them creating an ideal teaching and learning environment in their own classroom. Table 4.11 shows the major limiting factors reported by the respondents.

Table 4.11. Limiting factors identified by teachers (n=21)

Limiting Factors	Frequency	Percent
Students' poor attitudes, behaviour and lack of skills*	13	19
Limited science resources *	12	18
Curriculum restrictions and requirements*	9	13
Time allocated to science and time table	6	9
Teachers lack of skills and knowledge	6	9
Class size	6	9
Extra-curriculum pressures	5	7
Other responses	2	3
Lack of access to technology	2	3
Poorly designed labs and lack of access	3	4
Range of student ability	1	1
Teachers attitude	1	1
Lack of parental support	1	1
Co-ordinating large number of LSS teachers	1	1
Total	68	100

Although there were a large number of response categories, three categories contained 50% of all responses. Respondents reported that students' poor attitudes, behaviour and lack of skills the limited science resources were two common factors limiting teachers' success in their classroom. Curriculum restrictions and having to teach in order to prepare students for further lower school and subsequent upper school study was another limitation that teachers felt impinged on their lower school science classes. The following assertions are statements constructed from the major ideas that teachers brought with them to the CASSP study.

In Assertion 4.1 it can been seen that teachers participating in the trial acknowledged the importance of lower secondary science.

Assertion 4.1

Teachers recognised that lower secondary science is important in helping students make sense of the world around them and this should be its primary role.

Some teachers acknowledged that lower secondary science was still seen primarily as the springboard for upper school science.

Assertion 4.2

Teachers identified a large number of attributes of effective teacher. Teachers identified effective students as those who are interested, enthused and motivated to participate.

There were a number of differences between teachers' actual practice and their perceived ideal practice Ideally, teachers would spend more time performing group activities and basing their science around the relevant content, not having to focus on completing unit content. Teachers would ideally spend more time on assessing students' progress, and examining student prior knowledge and less time on grading and reporting. There was also a difference between teachers' styles, with 10% of respondents reporting that a quiet class is always the most productive while another 10% of respondents feeling that a quiet classroom is never productive.

Assertion 4.3

Teachers recognised that their practice was not ideal and they felt they would rather spend more time assessing students' progress and identifying their prior knowledge.

What are teachers' concerns and what factors do they feel prevent or limit them from reaching their gaols? Twenty-four percent of respondents reported that they were concerned about the effectiveness of the teaching-learning strategies that they were currently using in their classroom. The factors that were cited by the largest number of teachers were; poor student attitude, which also was a concern for many teachers; limited resources in science; and the curriculum restrictions and requirements, to use lower secondary science as a preparation for upper school science and parental and administrative expectations.

Assertion 4.4

Twenty-four percent of teachers expressed concerns about the effectiveness of the teaching/learning in their classroom.

Assertion 4.5

Teachers identified three major factors which limit their effectiveness in the classroom, these are; poor student attitude, limited science resources and curriculum restrictions/requirements.

Teachers' Journeys Through the Innovation

Concerns Regarding the Strategies Underpinning the Innovation

The student-centred inquiry strategies that were brought together as part of the CASSP trial are not unique to this study and many of the teachers may have been familiar with them. Questionnaire One asked teachers to rate the perceived usefulness of the strategies and any concerns they had about their implementation. Table 4.12 shows that the majority of respondents thought that all the strategies were very useful.

Table 4.12. Teachers' response to the question: How useful do you consider the following CASSP strategies? (n=21)

Strategy	Percent of respondents Very useful	 Somewhat useful	 Not useful
Increasing students' interest in science by setting lessons in real world context	86	14	0
The use of formative assessment to give feedback to teachers and students, and to plan for learning	75	25	0
Encouraging more student-centred learning	62	38	0
Use of investigations to promote inquiry in the curriculum	86	14	0
Teaching to promote deeper student understanding rather than superficial recall	86	14	0
Use of information technology to enhance student learning	62	38	0

The teachers were also asked to list any concerns that they felt about each strategy. The major concern expressed by 60% of teachers (Table 4.13) was their ability to find meaningful context for a wide range of students of different ability level, ethnic background and gender.

Table 4.13. Teachers' concerns about increasing student interest by setting lessons in real world context? (n=21)

Concern	Frequency	Percent
Difficult to find meaningful context for a range of diverse students	12	57
Lots of extra work expected by the teachers	3	14
No concerns/ no answer	2	9.5
Needs extra resources including funding and facilities	2	9.5
Detracts from real science and curriculum	1	5
Reduce content covered	1	5
Total	21	100

The concerns regarding the implementation of formative assessment into the lower secondary classroom outlined in Table 4.14, were more widely spread with the most significant concerns regarding time and the ability to asses and provide feedback to students in an already crowded curriculum. Nearly 40% of responses (*) suggested that the teachers did not understand what the term formative assessment meant.

Table 4.14. Teachers' concerns about using formative assessment to give feedback to teachers and students and to plan the learning. (n=21)

Concerns	Frequency	Percent
Time available to do assessment and provide meaningful feedback	7	29
Not useful assessment tool to teachers	2	9
Other responses	2	9
No concerns/ no answer	2	9
Student do not value this form of assessment	1	4
Needs more information about strategy*	3	13
Teacher expected to control and moderate task*	2	9
Does not meet parent and admin. expectations*	2	9
Answer relates to Outcomes not formative assessment*	2	9
Total	23	100

Teachers' concerns about encouraging more student-centred learning are listed in Table 4.15 below.

Table 4.15. Teachers' concerns about encouraging more student-centred learning (n=21)

Concern	Frequency	Percent
Extra work for teachers in planning and organising	6	20
Giving students skills to take control of their learning	5	17
Monitoring students; providing facilitation and guidance	4	13
Lack of resources and time in curriculum	3	10
Student motivation and poor behaviour	3	10
No concerns/ no answer	3	10
Assumes good content background for teachers	3	10
Accountability to parents and admin.	2	7
Allow too much specialisation not general enough	1	3
Total	30	100

Twenty percent of responses indicated that this strategy would require extra work for teachers in planning and organising, and 13% were concerned about teachers' ability to facilitate and monitor student's progress. Seventeen percent were concerned about the skills needed by students so that they could take control of their learning.

Teachers concerns about encouraging inquiry in the lower secondary science curriculum are summarised in Table 4.16.

Table 4.16. Teachers' concerns about encouraging inquiry in the curriculum (n=21)

Concerns	Frequency	Percent
Difficult to set up and hard to find materials	7	29
Students not used to open-ended investigations	6	25
No concerns/ no answer	4	17
Time constraints of the curriculum	2	8.5
Lack of adequate facilities	2	8.5
Assessment concerns	1	4
Student motivation and poor behaviour	1	4
Science understanding may not be fully developed	1	4
Total	24	100

The two most common concerns related to the difficulty of establishing inquiry based learning given the limited resources available (29%), and students' lack of experience and skills in inquiry learning (25%).

Teachers' concerns about teaching for deeper understanding instead of superficial recall are summarised in Table 4.17. Responses were split with 27 % of responses indicating no concerns about this strategy, while 23% of responses indicated that some rote learning was inevitable and important. "Some 'superficial recall' is still required (ie. science language of ions to write equations), some students learn best by rote learning" (Teacher 1). Other responses also noted that there is "conflict with current TEE/tertiary requirement for content background" (Teacher 3).

Table 4.17. Teachers' concerns about promoting deeper student understanding rather than superficial recall (n=21)

Concern	Frequency	Percent
No concerns/ no answer	6	27
Some rote learning still deemed necessary by teachers	5	23
Creates conflict with current requirements to train students for upper school	4	18
Students progress at different rates	2	9
Teachers need time, strategies and skills to implement this.	2	9
Changing student expectations of success	2	9
Other responses	1	5
Total	24	100

The final strategy examined was the use of information technology in the science classroom, which produced a very strong response from respondents who had many concerns (Table 4.18).

Table 4.18. Teachers' concerns about using information technology to enhance student learning (n=21)

Concern	Frequency	Percent
Logistical issues including hardware and software	13	41
Not the best use of classroom time, waste of time setting up and searching for information	10	31
Need to monitor student use to prevent plagiarising or accessing unsuitable material	5	16
Teachers concerned about over unnecessary use of computers	2	6
Teacher time and knowledge level	1	3
No concerns/ no answer	1	3
Total	32	100

Forty-one percent of responses were connected with logistical problems in the setting-up and running of the computers, reporting a lack of access to computers in the science laboratories and poor quality science computer programs. Other responses in this category reported broken, and/or outdated machines that were very slow or unable to access the server, not properly connected to printers and other hardware. This may also link with the category of concerns, which reported that setting-up the computers and running them wasted vast quantities of class time with 31% of responses falling into this category.

Although (Table 4.12 – 4.18) most teachers thought that these strategies were very valuable, there were a number of concerns about each strategy that needed to be addressed before these strategies could be implemented successfully into the science classroom.

Assertion 4.6

The Western Australian teachers were also overwhelmingly supportive of the intended CASSP strategies although they also expressed a number of concerns that needed to be addressed before teachers could implement these strategies.

Implementation of the Three Aspects of CASSP Model

Stage One – Half way into the innovation

At the midpoint of the innovation the teachers were again gathered together for the second professional development session and asked to complete Questionnaire Two. The questionnaire sought to elicit teachers' views about the implementation of the three aspects of the CASSP model on their teaching. The three aspects were professional development, curriculum resources and participative inquiry.

To begin with, the teachers were asked how their teaching was different this term, while teaching the new Energy unit. The responses summarised in Table 4.19 indicated that respondents had noticed a number of differences in teaching and learning in the first few weeks, with only five percent of responses indicating the science was no different this term.

Table 4.19. Teachers' responses to the question: What aspects of the teaching and learning of the new Energy unit this term have been different from previous terms? (n=21)

Differences in teaching and learning	Frequency	Percent
Increase in practical and open-ended activities	8	20
Use of different book and effect of T/L; less handouts	8	20
More discussion and interaction with whole class	4	10
Less variation in activities/presentation	4	10
Changes in lesson structure	3	7
No response	3	7
Time; tasks take longer as students control pace	3	7
Responsibility for learning on students	2	5
Little or no change	2	5
Other responses	2	5
More group work	1	2
More student centred; less teacher control	1	2
Total	41	100

Twenty percent of responses stated there had been an increase in practical and open-ended activities and another 20% had stated that the different resources had resulted in them needing to prepare fewer handouts.

Teachers were asked about the effectiveness of the curriculum in improving the teaching and learning of Year 9 science this term. The teachers were required to determine the effectiveness of the student and teachers book and how the materials could be improved. Subsequently the teachers were asked how they were selecting, using and adapting the material to cater for different student abilities within their lower school classrooms.

When asked about the effectiveness of the materials, 59% of responses indicated the student book was effective or very effective. No responses indicated the teacher book was ineffective, however only 24% of responses indicated it was effective and most responses (76%) suggested that it was OK.

Table 4.20. Teachers' responses to the question: How effective were the materials in the student and teacher book? (n=17)

	Percent of responses				
	Very effective	Effective	OK	Ineffective	Very ineffective
Student book	12	47	29	6	6
Teacher book	0	24	76	0	0

Respondents were then asked to comment on any aspects of the student and teacher book impacting on them so far, and Table 4.21 shows the number and type of negative and positive comments about the student book received. Responses were split almost equally between positive and negative comments; however, there was no significant area that received more criticism or praise in the responses.

Table 4.21. Teachers comments about the use of the student book. (n=21)

Comments	Frequency	Percent
Positive Comments		
General non specific positive comments	5	18
Clarity of tasks	3	11
Activities and practical work very good and easy to use	2	7
Use of materials and resources	1	3.5
Positive student reaction	1	3.5
Explanations and diagrams good	1	3.5
Good at motivating and self direction for students	1	3.5
Negative Comments		
General non specific negative comments	4	14
No response	3	11
Catering for lower ability students only	2	7
Instructions hard to follow	2	7
Need for additional material	1	3.5
Time problems	1	3.5
Questions hard to determine	1	3.5
Total	28	100

At this point teachers were still in the early stages of the program and many concerns they were experiencing were in the actual day to day use of the materials, not in the underpinning ideologies. This can be seen in Table 4.22 when respondents were asked about the changes they would make to the materials, the highest percentage, 18% of responses wanted the minor typographical and presentation errors corrected. In total, nearly 40% of responses (*) relate to minor concerns of presentation, typing errors, unclear images, extra equipment not specified and changes to the wording of instructions to improve clarity.

Table 4.22. Teachers' responses to the question: What changes would you make to the student and teacher books? (n=21)

Changes that should be made to teachers and student books	Frequency	Percent
Changes to presentation; fix errors*	7	17.5
Need extra material; notes, self quiz	6	14.5
Change to structure and layout of the book*	5	13
No response	5	13
Make task instructions clearer*	3	7
Change content to increase theory, provide more factual information	2	5
Changes to activities; open-ended, improve structure	3	7
Need more explanations either general or specific	2	5
Changes to specific topics	1	3
Changes to recording information*(include tables to fill in)	1	3
Catering for extension	1	3
Need for assessment items (esp. related to outcomes statement)	1	3
Changes to length of lessons	1	3
Catering for low ability/ESL students	1	3
Total	39	100

It was important to understand not just what the respondents thought about the materials but also how the materials were utilised in the classroom, including how teachers were choosing and running activities. Respondents were asked to list the factors that influenced their choice of activities selected, and these are presented in Table 4.23.

Table 4.23. Teachers' response to the question: What factors influenced your selection of activities taken by students? (n=21)

Factors	Frequency	Percent
Choice based on current courses run by schools	8	23
Students ability, interests and needs	7	20
Other response	4	11
Equipment and laboratory availability	3	8.5
Logical sequence best for understanding	3	8.5
Teachers preference based on confidence and ability	3	8.5
No response	3	8.5
Nature of activities	1	3
Time constraints/time of day/time available	1	3
Activities that covered the main ideas	1	3
Level of student understanding	1	3
Total	35	100

There is a wide dispersion of factors that teachers must consider when planning their lessons, these include; student issues (ie. ability, interest, prior knowledge, needs); teacher issues (ie. confidence, experience, level of expertise); school requirements (ie. curriculum frameworks, upper school pre-requisites, parental expectations, other teachers expectations and influence) and; logistical issues (ie. equipment availability, other classes courses, classroom availability). Responses indicate that teachers felt the biggest influence was how closely current activities followed the pre-existing Energy objectives from previous years (20%).

Respondents were also asked if they used the resources to allow different students to work on different activities, and 68% of responses indicated that students did not work on different activities within the class. The two major reasons given in Table 4.24 related to concerns about student behaviour (24%) and insufficient equipment and resources (16%).

Table 4.24. Teachers' responses to the question: Have you used the resources to allow different students to work on different activities? (n=21)

Factors	Frequency	Percent
Yes		
Some activities as class group, some as choice	2	8
Student given activities to work on at own pace	1	4
Groups circulate through activities	1	4
Student who work ahead, complete extension activities	1	4
No		
Student management concerns	6	24
Difficulty with equipment and resources	4	16
Other response	3	12
"No" response, no explanation	1	4
Teachers prefer all students work together	1	4
Students require teacher directed work	1	4
Safety concerns	1	4
No response	3	12
Total	25	100

Finally respondents were asked to comment on how they adapted the materials for their class (Table 4.25).

Table 4.25. Teachers' responses to the question: Have you adapted the materials or approaches for your class? (n=21)

Adaptation of materials or approaches	Frequency	Percent
Added other tasks and activities	6	27
No responses	5	22.5
Changing approaches/activities for classes' different abilities	4	18
Changing sequence of activities	3	13.5
Other response	2	9
Include more teacher directed lessons	1	5
Add or change group set up	1	5
Total	22	100

As seen in Table 4.25, 27% of responses indicated that extra tasks and activities had been added to bring the course in line with the objectives written for the unit in previously years. Other changes were adapting materials for very low or high ability groups (18%) and changing the sequence of activities (14%). One teacher with both high and low ability students reported "with the 9.3 (high) I add extra work/concepts, with the 9.6 (low) I break it down with vocabulary and stepping out strategies" (Teacher 15).

Teachers' rating of the professional development was considered to determine its effectiveness in addressing the needs of the teachers (Table 4.26). Just as different students have different developmental needs, teachers also have differing needs as they are at different stages of their professional learning journey.

Table 4.26. Teachers' overall rating of the professional development. (n=19)

	Percentage of responses				
	Very effective	Effective	OK	Ineffective	Very Ineffective
Initial PD	16	79	5	0	0

Table 4.26 shows that 95% of the teachers rated the PD as effective or very effective 95 % of the time.

Teachers were asked to comment on the most effective component of the PD and there was a wide range of replies as seen in Table 4.27.

Table 4.27. Teachers identification of the most effective components of the professional development (n=21)

Components of the professional development	Frequency	Percent
Learning new strategies/approaches to teaching	8	28
Collaborations with other teachers	4	14
Theory behind cooperative learning	3	10
Questioning techniques	2	7
Peer presentations	2	7
Other responses	2	7
Good pace	1	4
Great presenter	1	4
Physics activities	1	4
Group approaches to problem solving	1	4
PI/discussion of PI	1	4
Time for discussion and questioning	1	4
No response	1	4
Total	28	100

Teachers valued the time spent examining the teaching and learning strategies with 29% of responses indicating that this was the most effective component of the professional development.

From Table 4.27 respondents also valued the use of collaboration and discussion between teachers, and this forms the third aspect of the CASSP model, called participative inquiry (PI). While the other aspects of the CASSP model were very familiar to teachers in their current form, the formalising and naming of time teachers spend talking and reflecting with other teachers is a less familiar idea. The CASSP teachers went back to their schools with a number of PI questions and the undertaking that the program coordinator at each school would undertake and facilitate the PI sessions where teachers would be encouraged to discuss the teaching and learning occurring in their Year 9 science class. Table 4.28 below shows the format of the PI carried out in the schools.

Table 4.28. Teachers' response to the question: How has the PI been implemented in your school? (n=21)

	Percent of Responses			
Type of PI	Frequently	Occasionally	Infrequently	Never
Informal PI	72	22	6	0
Semi Formal PI	0	53	20	27
Highly Formal PI	6	29	29	35

Table 4.28 indicates that the majority of the PI in the first five weeks of the trial took the form of informal unplanned meetings in staff rooms between classes. Only 6% of teachers reported participating in highly formalised PI or semi formal PI frequently. In one case, the teacher reported she did not realise that there were PI questions in the materials.

Stage Two – End point of the innovation

After the completion of the trial teachers were asked to comment on the impact of the CASSP project on their teaching in Questionnaire Three. This sub-section concentrates on two aspects of the model, the impact of the materials on classroom practice, and focusing on the development of the participative inquiry (PI).

The resources were examined and teachers were asked to map their classroom journey through the activities in the student book and evaluate them. Teachers completed a wide variety of activities, with some respondents completing only a few activities, others many more, some in the suggested order in the student resource book, others in a different way. The teachers' resources were considered in more detail at this point, with respondents asked to evaluate the areas of the teacher print resources and the web site. The results are summarised in Table 4.29

Table 4.29. Teachers' responses to the question: Please evaluate the teachers' resource book and web site, ticking the most appropriate box in the table. (n=21)

	Percentage of responses					
Teacher resources	Not used	Very useful	Useful	OK	Little use	Poor
Teaching strategies	11	11	44	33	0	0
Questions	12	6	47	24	12	0
Commentary	12	12	29	41	6	0
Background	11	6	39	11	22	11
Resource sheet	11	6	61	11	6	6
Web site assessment	12	24	41	12	12	0
Web site solutions	18	24	41	6	12	0

A number of teachers were not using the teachers' resources (11%) or the web sites (12-18%). Some teachers reported that they had had trouble accessing the web site and the web solutions were not posted-up until near the end of the study, which may be why it was indicated that they were not used. Teachers', who had accessed the web site, indicated that the site was useful or very useful (65%). The background material was of little use or poor (33%), however, the resource sheets were considered useful or very useful by 67% of responses and all of the responses indicated that the teaching strategy information was OK, useful or very useful.

Respondents were again asked to consider their teaching practice and the time spent on different aspects of classroom teaching (Table 4.30), they had already considered this in Questionnaire One and mapped their time spent in a pre trial actual class and their ideal classroom (Table 4.7).

Table 4.30. Teachers' response to the question: Please consider a typical Year 9 Energy unit lesson this term and estimate the time you spent on the following. (n=21)

Teaching and learning activities	Time allocation Percent	Standard deviation
Teacher explaining to the whole class	13	6
Whole-class discussion	22	12
Group-based practical and activity work	52	14
Giving notes to students	6	4
Students working individually including from the text book	8	5

Comparing the results for last term (Table 4.7) and this term (Table 4.30) it can be seen that there was less time being spent on chalk and talk this term (ie. teacher talking to whole class) (13%) reduced from the last term's (actual) classroom (17%). The amount of time spent in whole class discussion increased from last term (12%) to this term (22%), this is greater than the teachers' ideal (18% (ideal) Table 4.7). An increase can also been seen in the group-based practical and activity category where the time spent here has increased from 37% last term to 52% this term, surpassing the teachers ideal of 47% (ideal Table 4.7). The categories of giving notes to students and students working from text have both dropped, student notes by half from 12down to 6% and students working from text from 24% down to 8%, a significant drop of two thirds.

Questionnaire Three also asked teachers about the strategies they used and the frequency with which they used them. Table 4.31 summarises these data.

Table 4.31 Teachers' responses to the question: Please determine which of these strategies have been used more or less frequently in your Year 9 science classroom this term (n=21)

Strategies	Percent of responses Less	No change	More
Students copying from the board/OH	50	44	6
Teacher explaining	35	53	12
Smaller group discussions and activity work	0	33	67
Using cooperative groups for class activities	0	28	72
Using open-ended questions, and extended wait time	6	35	59
Using more examples that relate classroom science to real life experiences	6	50	44
Conceptual explanations developed after activity and experiences	0	39	61
Students participate in guided inquiries and open-investigations	0	44	56
Fewer concepts are covered but students have more experiences of these	6	24	71
Formative assessment is used during the topic	6	61	33
Summative assessment is used at the end of the topic	6	89	6
Diagnostic assessment is used at the start of the topic	6	39	56

There were changes in teachers' practice with 50% of responses indicating less copying of notes from the board and an increase in the amount of group work (67%) in the classroom. Teachers felt that they were covering fewer concepts but addressing them in greater depth (71%) this term. Summative assessment at the end of the topic is unchanged in 89% of respondents, however, there was an increase in the amount of diagnostic assessment (56%) and formative assessment (33%) this term.

Teachers were also asked again if they were modifying or differentiating their materials and approaches to cater for students with different needs. At the second PD there was discussion about some teachers believing that they had to remain 'true' to the study by not making changes to the material, however, teachers were encouraged to adapt the materials and their approach to make their practice more effective (Tables 4.32 and 4.33).

Table 4.32. Teachers' response to the question: Since the discussion at the second PD, have you used the resources to differentiate instruction within the class, with different students working on different activities? (n=21)

Teachers' reasons for differentiating practice	Frequency	Percent
Yes		
Students choose activities	7	31
Student given activities to work on at own pace	3	13
Modified and extra material added	1	4
Student who work ahead, complete extension activities	1	4
No		
Student management concerns	4	18
Difficulty with equipment and resources	2	9
"No" response, no explanation	1	4
Other response	3	13
No response	1	4
Total	23	100

Table 4.33. Teachers' response to the question: Have you adapted the materials or approaches to make them more effective for your students? (n=21)

Adaptations to materials	Frequency	Percent
Modified specific activities - more time efficient	8	22
Adding material not covered in resource material	6	17
More student centred due to management issues	4	11
Modified to motivate students	4	11
Demonstrate and modify for better understanding	3	8
Increase variation of teaching method	3	8
Change the order of activities completed	3	8
Other response	2	6
Modified for safety issues	2	6
No modification	1	3
Total	36	100

The differentiation of materials to suit the differing needs of the students increased from 20% (Table 4.24) at the mid point of the trial to 51% at the end of the trial (Table 4.32). The major reason for not allowing different students to attempt different task is still student management/behaviour (17%), however, teachers are empowering students more frequently to choose activities (30%) and work at their own pace (17%). Teachers' were adapting materials to make them more time efficient (22%) and add material teachers felt were not included (17%).

Teachers' perceptions of and the benefits derived from the participative inquiry (PI) were again considered in this section of the CASSP journey (Table 4.34).

Table 4.34. Teachers' responses to the question: What sorts of PI meeting have occurred in your school this term? (n=21)

	Percent of responses			
Type of PI	Frequently	Occasionally	Infrequently	Never
Informal PI	75	20	5	0
Semi formal PI	21	32	32	16
Highly formal PI	12	24	29	35

There has been very little change in the type and frequency of the PI from Questionnaire Two (Table 4.28), with the majority of PI (75%) still being carried out informally between classes and over coffee (Table 4.34). Teachers were also asked about the benefits of the PI sessions (Table 4.35).

Table 4.35. Teachers' responses to the question: The greatest benefits of the PI discussion have been?

Perceived benefits of PI	Frequency	Percent
Collegial discussion between teachers	7	28
Clarification and reinforcement of CASSP strategies*	5	20
Problem-solving due to discussion by teachers	4	16
Individual reflection about strategies	3	12
Having time set aside	2	8
Other responses	2	8
Contextualise project to wider school	1	4
Improved confidence	1	4
Total	25	100

Teachers indicate that the collegial discussion between teachers is the greatest benefit of the PI (28%), however clarification of the inquiry based strategies (CASSP strategies*) (20%) was also important to teachers.

In this section an attempt has been made to capture teachers changing opinions, perceptions and concerns as they move through the trial. Changes have been observed in teachers' perceptions of the strategies and approaches utilised in the classroom. Teachers' understanding and use of the three components of the CASSP trial have been examined in depth. These include the resource material and its application in the classroom, the use of professional development to help facilitate understanding of the underpinning inquiry-based strategies and participative inquiry to encourage teachers to reflect on and discuss their current practices.

Assertion 4.7

Ninety-five percent of teachers rated the professional development as effective or very effective with collaboration and learning new strategies as the two major benefits.

Fifty-nine percent of teachers rated the student resources rated as effective or very effective, with teachers' concerns relating to the presentation of the material.

Seventy-two percent of the participative inquiry was conducted informally, with teachers citing the major benefits as peer collaboration and reinforcement of the CASSP strategies.

Impact on Teachers' Professional Learning

Section four examines teachers' opinions about the Program and its impact on teaching and learning. Teachers were asked what they felt the project had achieved for them, how their teaching had changed (Table 4.36), and the future of the CASSP project.

Table 4.36. Teachers' responses to the question: What have been the main differences in your teaching this term? (n=21)

Main differences in teaching	Frequency	Percent
Increase in group work/practicals/discussion	10	31
Increased use of other CASSP strategies	7	22
Use of new materials and effect on students	6	19
Learning is more student centred	4	13
Assessment changes – less summative	2	6
Other responses	2	6
Little or no change to teaching this term	1	3
Total	31	100

Teachers felt their practice had become more focused on group work (32%) and more student-centred (13%), with a greater use of inquiry based (CASSP) strategies (23%). Many teachers made discoveries, like Teacher 2 who found "a greater awareness of the level of knowledge held by students at the beginning of the topic".

Data summarised in Table 4.37, demonstrated an increase in focus on the teaching and learning in the classroom (36%) and a greater understanding of the CASSP promoting strategies in 31% of responses. One head of department reported "the teachers involved have enjoyed using the resources and have had success in exploring different pedagogical strategies with their classes" (Teacher 8).Some teachers (14%), however, reported achieving very little, or nothing through this project.

Table 4.37 Teachers' responses to the question: What do you feel you have achieved through this project? (n=21)

Project achievements	Frequency	Percent
Increased focus on teaching and learning in the class	13	36
Gained greater understanding of CASSP strategies	11	31
Collegial experiences and networking	4	11
Little achieved	4	11
Gained new resources in the materials provided	3	8
No change to my practice	1	3
Total	36	100

Teachers were then asked if the trial had been valuable, and would they support an extension of the pilot and development of more resources to cover other lower school science topics. The responses were overwhelming with the majority of teachers supporting the extension of the pilot into more schools and the extension of the materials into other lower secondary science topics.

As one teacher wrote:

> "I would love to see more units made up to cover other strands and would certainly be keen to be involved in future projects like this one" (Teacher 1)

It is acknowledged that not all the teachers felt that they benefited from participating in the study, however, the majority of the teachers felt that the trial was of benefit to them. As these teachers reflect "I'm tired (very tired) but thanks it was worthwhile and useful and I am learning everyday" (Teacher 22) and "simply to observe the genuine value of this exercise to the ongoing development of good teaching" (Teacher 3).

Assertion 4.8

The majority of teacher (91%) reported changes to their classroom practice with the most common changes being on: increase in group work/practicals/discussion (32%); increased use of other inquiry strategies (23%) and increased student-centred learning (13%).

Assertion 4.9

Eighty-five percent of teachers reported benefiting from the CASSP trial. The most common benefits reported were: increased focus on teaching and learning (36%); and, a greater understanding of CASSP strategies (31%).

Impact of the CASSP Program on Students

This final section examines teachers' perceptions about two important areas, firstly students' engagement and enjoyment of the topic and secondly students' learning this term. In the final section of Questionnaire Three, respondents were asked if they though students had enjoyed science that term. The responses are tabulated in Table 4.5.1 below, which shows 57 % of teachers thought their students had enjoyed science.

Table 4.38. Teachers' response to the question: Do you think your students have enjoyed science this term? (n=21)

Teachers' opinion of students' enjoyment	Frequency	Percent
Yes the majority of students enjoyed the unit	12	57
No the majority of students did not enjoy the unit	2	10
Class was split with half enjoying unit, other half not	4	19
Students seemed to like the unit but said they did not in student survey	1	5
Students enjoyed some aspects of unit only	1	5
Students did not see any change from normal	1	5
Total	21	100

It is interesting to note the comments from some teachers as a way of explaining the number of students who did not enjoy the unit, Teacher 23 had received comments (that) have ranged from very negative to very positive. Most (students) believe the activities to be enjoyable, however, they wanted more content and exercises to consolidate what they have learnt in the investigations (Teacher 23).

Another teacher reported that students' negative comments may have stemmed from their expectations about teaching and learning. He commented

> " The assessment style provided by the project materials left the students feeling unsure about their test performance as they were used to more content-based, know it or not items" (Teacher 16)

This comment was confirmed by examining what teachers felt that their students had gained from this topic. Twenty four percent of responses in Table 4.5.2 felt that the topic had encouraged students to be more independent learners, a necessary skill that this teacher had noted was lacking in the students at his school by the comment below:

> "We have exposed weaknesses in our student-body that have developed as a result of our past methodology. Notably our students lack independence and tend to be results driven" (Teacher 16)

Table 4.39 Teachers' response to the question: What have your students gained from this topic? (n=21)

Teachers' perception of students' gains	Frequency	Percent
Becoming more independent learners	6	24
Other responses	6	24
Increased understanding of concepts	3	12
Developing investigative and group skills	3	12
Increased engagement and enjoyment	2	8
Increased amount of practical components in class	2	8
No response	2	8
Nothing/ very little	1	4
Total	25	100

Assertion 4.10

Sixty-two percent of teachers reported their students enjoyed part or the entire unit. The majority of teachers (78%) felt that their students had gained from the CASSP project and the major benefits including; students becoming more independent learners (24%), developing investigative and group skills (12%) and increased understanding of concepts (12%).

Summary

This Chapter examined teachers' expressed beliefs about the teaching and learning that is currently occurring in their science classroom, and their beliefs about their ideal science teaching and learning and best practice. The Chapter follows teachers' experiences throughout the innovation mapping their changing concerns about the effectiveness of the innovation and its ability to meet their needs and consequently those of their students. This culminated in examining teachers' perceptions of their learning experiences. Teachers were asked if they considered the project had long term benefits for them and other lower secondary science teachers. The final section considered the impact of the project on the students, by examining the teachers' perceptions of their students' experiences.

CHAPTER 5: CASE STUDY SCHOOL A: TEACHERS' PROFESSIONAL LEARNING EXPEDITIONS

Introduction

To gain a deeper understanding of the teachers' beliefs about the teaching and learning process, and their understanding and utilisation of the strategies promoted in the trial, the Researcher sought to interview and observes a small number of teachers in depth. This formed the case study component of this research study.

Teachers' Professional Learning Journeys

The term 'teacher change' has been used so far in this thesis to describe changes to teachers' practice as they engage in a professional learning program, however, this is too narrow a term to describe teachers' long-term learning. The term 'teacher change' connotes a single process with distinct start and end points, whereas teachers learn continuously throughout their professional lives, when teaching their classes, reflecting with their colleagues or participating in innovations, such as CASSP. Consequently teachers' 'professional learning journey' is a term which better captures teachers' continuous and progressive growth in knowledge and skills as a teacher.

The majority of the teachers participating in the CASSP trial only had their beliefs and experiences probed at intervals throughout the trial using questionnaires. To provide a richer account of the CASSP experience, four Western Australian teachers were observed more closely, and their professional learning expedition through the CASSP project is examined here in-depth. The experiences of these four teachers are examined; case studies of two teachers at School A in Chapter 5, and two teachers at School B in Chapter 6.

As with all journeys, this interlude has a point to embark from, a framework for the journey and a destination. Forming the commencement point of the journey are teachers' beliefs and concerns about teaching and learning collected at the beginning of the Term by the Researcher using a questionnaire, classroom observations and interviews. The Researcher then sought to describe the teachers' success in evolving their practice from teacher-centred to a more student-centred approach. Teachers' practices are examined using the framework below to classify the classroom observations and interviews according to the research questions and key aspects from the conceptual framework. The research questions addressed through the case studies are: How do the teachers use the innovation? How successfully do the teachers implement the innovation? What concerns do the teachers bring to and have during the innovation? What factors influence the change process? The guidelines are;

1) How successfully do the teachers utilise and implement the key CASSP strategies, making changes in their practice?

   Key aspects:

   i) Teachers' pedagogy: Contextualising material
      Placing experiences before explanation
      Using students' prior knowledge
      Using inquiry-based learning (e.g. investigations)

   ii) Students' learning and behaviour:
      Development of group skills
      Development of students as independent learners
      Students' attitudes and engagement in science

2) How do teachers' concerns evolve and reflect their ability to identify and make changes to their practice?

3) How do constraints impact on the teachers' ability to make changes, and do these constraints change during the trial?

At the end of the trial, the Researcher sought to determine how successful the teachers felt they had been in making changes to their practice; what the teachers' considered their practice was like at the conclusion of the trial; how useful the teachers' considered the professional development, curriculum resources and participative inquiry components were in facilitating changes in their practice.

Pseudonyms

The teachers from both schools have been given pseudonyms to protect their identity. The two teachers from School A have been allocated the pseudonyms 'Ann' and 'Amy', and the two teachers from School B, will be known as 'Beth' and 'Bob' in all reports of this study.

School and Teacher Selection

There were two schools that were in part self-selected to be the case study component of the trial with two teachers from each school invited to be part of the study. These teachers were invited to participate because they had a wide range of teaching experiences in different specialty areas. During the initial professional development session at the end of second term, these teachers were invited to participate in three interviews during the 10 week trial and allow the Researcher to observe as many of their Year 9 science classes as possible during the trial. The Researcher did not participate in the classes, but observed the teacher and students from the rear of the classrooms and kept a diary of the lessons attended (Appendix 3.2) and completed a Lesson Observation Sheet for each lesson attended (Appendix 3.3). The Researcher also attended the formal participative inquiry sessions scheduled at both schools.

Context

School A is a church-based K-12 independent school for girls, which has regular observation of religious services within the school timetable. A large proportion of students at School A seek entrance to university courses at the completion of Year 12. It is a fee-paying school, and the cost of tuition, uniform and other extra curricular activities precludes students from low socioeconomic areas from attending, unless they receive a scholarship. The school has a boarding house to accommodate students from rural areas, interstate and overseas, and day girls also attend from the Perth metropolitan area. The school also has a number of fully functional computer laboratories, as well as extensive playing fields, tennis courts and pool.

Students have a specific school uniform and their compliance to all aspects of the uniform code is strictly enforced. Students are all assigned a pastoral care teacher who meets with his/her students for a short time everyday to ensure the students receive school notices and act as the point of first contact for students experiencing difficulties with any aspect of school life. Students are also organised into year groups under the care and guidance of a Year Coordinator, who organises any excursions, camps and activities for students, as well as monitoring student behaviour. Observation of activities at School A and discussion with staff indicates that students were able to participate in a wide range of extra curricular activities during and outside of school hours, with many of these involving extensive teachers' participation. During the course of the trial, there were several whole school activities, ie. drama day, sports day and Year 9 day which reduced the number of lessons available for teaching the Year 9 science course.

Facilities and Resources

There is a large number of dedicated science laboratories in the school and many were set up as specialised classrooms for particular disciplines. For example, the marine science classrooms contained a large number of marine specimens, tanks of aquatic specimens, posters and specialised marine equipment as well as the general classroom resources. The general classroom facilities were extensive, with all classrooms being equipped with class sets of glassware, Bunsen burners, tripods, tongs and other general equipment including all safety apparatus. For the teachers, each classroom contained overhead projectors and built-in screens, white boards, with some also having chalkboards. All classrooms were linked by preparation areas from where the laboratory staff wheeled in the necessary trays of equipment. There seemed to be plenty of equipment, often with enough modern resources so that two classes could run the same experiment at the same time. The classrooms themselves were designed with wide side benches, with plenty of power points to enable students to perform experiments on the side benches and leave their books at their main desks. Students all had their own text book and file which they were required to bring to each science lesson. There were also class sets of other text books around some of the rooms, which the teacher could access if he/she wanted.

Science Department

The science department at School A comprised seven female and two male teachers, located in two science staff rooms, one upstairs and one downstairs in the science buildings. This separation of the science teachers precluded informal participative inquiry for one member of the trial as all the other teachers involved in the trial were in the other staff room. The project coordinator was not teaching Year 9 science, however, maintained a keen interest in teachers' experience.

Classes

The Year 9 cohort was divided into six classes; five were in the top stream and one class in the second stream. Classes in the top stream were studying topics that would prepare these students to study upper secondary science subjects (ie. physics, chemistry, biology etc). The second stream comprised one class of the lowest achieving students in the year who were not studying topics deemed necessary pre-requisites for upper school science. The Year 9 topics chosen for the second stream class to study were at the discretion of the teacher, however, they closely mirrored the top streams topics.

Case Study of Ann

Background

Ann was approximately 40 years old and had been teaching science at the school since she graduated from her science education degree 25 years previously. She said she had always been a teacher even as a child, giving classes to her siblings and so the logical progression had been to formalise this with her degree. She chose science education due to her love of Biology fostered by her Year 11 Biology teacher.

Class

Ann taught two Year 9 science classes as well as a Year 9 outdoor education class, and an upper school Biology class. The Year 9 class observed by the Researcher was an above average class.

Teacher's Beliefs and Concerns

Ann professed to be ready for change, she said that for the last few years she had been concerned about how effective she was in the classroom and was reflective about her teaching

> ...I know I am not a good teacher, there's things I had to change and I don't know how to do it, I want some PD and I want some ways of learning 'how to do it' and this has come along and it's just what I have been hungry for (Interview two, 30/8/02).

In the initial interview Ann stated she believed that teaching science was important as it furnished students with the skills to help them make sense of the world around them. She reported that for her, teaching lower school science was about:

> giving kids that kind of basic understanding so that when they are a bit older and they are trying to work out how this works or what to do here or safety aspects and to satisfy their natural curiosity and to have an understanding of the world around them.
>
> (Interview one, 22/7/02)

When asked about effective teaching and learning Ann expressed her concerns about the changing nature of children's development, not just in the classroom but also in their home environment. She felt that students are having less opportunity to participate in concrete experiences, to manipulate and play, she stated "...they need lots of play time". This she perceived is shaping the needs of students in the classroom, the need for the teacher to provide play time for students, to structure their experiences and persuade them to ask questions (Interview one, 22/7/02).

This need for play and the perceived 'fullness' of the school science curriculum gave rise to Ann's major concern, time. She reported that with "...all the topics and we have to teach all of this and we've only got this much time and it all has to be taught and we all teach at the same time and we all have exams" (Interview one, 22/7/02) that teachers become highly stressed. She felt that this provided a very rigid structure in her department with lots of topics to cover, and with the need to increase practical work to give students concrete experiences resulted in a fully packed curriculum with little or no time to teach for understanding. Ann felt her teaching was "too teacher-centred". She wondered if with all the other extra curricular activities that she is involved in, and organising activities and equipment for her class, "being teacher-centred" was the easiest way of coping with her perceived lack of preparation time. As she then stated:

> ..I guess I have started doing in the last few years to get through the material is perhaps more demonstrations and stuff, where we get them all together and we demonstrate some of the activities, and that way I know I have knocked those activities off nice and quickly and we can get on to the next material.
>
> (Interview one, 22/7/02)

To become more effective she wanted to see an increase in the amount of group activities in her class, and reduce the number of teacher demonstrations. Ann felt that students needed "to be motivated, they need lots of playtime, and then they need to be structured, they need to have the answers, they need the opportunity to ask questions.... and some summaries to help explain the meanings" (Interview one, 22/7/02).

The Journey

Ann's hope for the CASSP trial was that it would reduce the time and content pressure that she had felt under and allow for "a lot more flexibility" in her classroom. At the initial PD, the teachers from the school decided that they would attempt all three modules (ie. energy, electricity and light), however, at the time of the first interview informal discussion had resulted in the teachers reviewing their aims to attempt all three sections. In interview one, Ann explained how the Year 9 teachers had decided that they would start with the Light module and then move through the Electricity module and then on to the Energy module if they had time. They had already taught aspects of Energy the previous year. Instead of teaching to predefined objectives set before the unit started, as was normally done, Ann reported that two weeks into the trial the teachers would meet to discuss how they were progressing through the topic. The usual assessment of the topics was to use the objectives set out in the textbook, which had been written based on the pointers of the WA curricular (Education Department of Western Australia, 1998). Ann had said that this year she was head of Year 9 science and was "trying to focus people a little bit more on what the framework says… rather than what the textbook pointers are". She then noted that "…having staff that have taught in science for a long long time quite often they are quite resistant to change" (Interview one, 22/7/02). In order to prevent the teachers falling back to their previous objectives and tests, the project coordinator stated that he would write the end of topic test. He indicated he would base it on the work they had covered up to that point, using the assessment bank of questions set out on the CASSP web site. As Ann predicted in interview one this dramatic change in the assessment structure caused several of the trial teachers concerns as the Term progressed.

The shift away from the traditional assessment and objectives released the time and content quandary that Ann had expressed concerns over. After several lessons at the start of the Term, she reported how great it was not to be 'racing through material' to cover the objectives in the pre-written test (Lesson Observation, 23/7/02).

Ann discussed the professional development and the curriculum resources components of the CASSP model briefly at the initial interview. Ann felt she benefited greatly from the PD she explained she

> had expectations that the PD was going to be really worthwhile and really good, and that we were going to see and be involved with doing some activities ourselves and that is what happened and (I was) ultimately very pleased.
>
> (Interview one 22/7/02)

She did express a few concerns about how much of the activities she could fit into her 45 or 50 minute lessons, as she presumed all the other schools had access to double periods and/or longer single sessions. These concerns were classified as utilisation concerns. These time constraints impacted on the very first lesson, which was cut short due to a school assembly (Lesson Observation, 23/7/02). This prevented Ann from being able to start the section she had planned and meant she had to re-order equipment and change her other orders for the remainder of the week. Another lesson was lost in the first week due to the Chemistry Quiz and individual students often missed lessons due to specialised extra curricular lessons mainly music or sport.

<u>The first few weeks</u>

In the first weeks, Ann found it difficult to move away from demonstrating the equipment to the students. She felt it was important that students understood how the equipment worked, however, this took between 10 to 15 minutes cutting down student activity time to only a few minutes in some lessons (Lesson Observation, 25/702). Students did not work well in groups initially, intent only on producing written answers to questions. They often examined the instruments/equipment without any discussion (Lesson Observation, 25/702). The students seemed to be waiting for the teacher to tell them what to write down because when she did not, asking lots of questions instead, there was a buzz of confusion echoing around the class (Lesson Observation, 29/7/02). Ann did ask the students to complete the diagnostic questions from the resources as a task, in silence. No comment was made or feedback give and therefore students were unsure as to why they had completed the task. Ann contextualised the work on light, probing students understanding about luminous and non-luminous objects. Students gave answers to questions again expecting confirmation if they were right, however, Ann did not provide this and the students became a little more disgruntled (Lesson Observation, 29/7/02).

Ann did express a few concerns about her knowledge of some areas of the unit, the discussion on optical instruments opened up a number of questions from students that

Ann seemed unsure of, and at one stage asked the Researcher for an answer (Lesson Observation, 25/7/02). When the discussion is more directed by student questions than under teacher direction, the teacher requires more extensive background knowledge to field more unusual questions. After the lesson, Ann said that although she had taught the topic a number of times, physics was not her area of expertise and she was much more comfortable in her own biological sciences area (Lesson Observation, 30/7/02). This was demonstrated in a lesson later in the Term, when the students were discussing the eye, the teacher was able to highly contextualise the lesson, questions flowed around the topic more easily and the students directed the topic through their questions rather than the teacher controlling the questions asked. (Lesson Observation, 23/8/02).

Another of Ann's concerns was the lack of time within the lessons, her initial introduction and demonstration often took longer than anticipated, and consequently there would only be time for a shortened group activity and little or no time for group discussion and drawing conclusions. Consequently, the next lesson would start with a review from the lesson before and then the group activity for that lesson would be pushed back further and further (Lesson Observations, 29/7/02 and 30/7/02). Ann was aware of this problem, mentioning it several times and sought to rectify it by introducing worksheets (Lesson Observation, 30/7/02) for students to complete. The use of worksheets allowed Ann to move quickly through lessons, maintaining some control of student learning but not exerting as much control as previously.

There was plenty of informal participative inquiry discussion amongst teachers in the science staffroom about the time it was taking to complete activities and which activities could be excluded (Lesson Observations, 30/7/02 and 31/7/02). Staff collaborated on worksheets, and adapted them after feedback from colleagues. For example, the Star activity, which was simplified to a triangle activity due to time pressures after feedback from other science staff in the CASSP trial (Lesson Observation, 31/7/02)

In the next few weeks Ann became more confident at allowing the students to take more control of their learning (Lesson Observation, 30/7/02). She still condensed and formulated tables and identified questions to complete on handouts based on the activities from the resource material (Lesson Observation, 30/07/02) and the time available for group activities had increased to 35 minutes in some lessons (Lesson Observation, 30/7/02). Ann was enthusiastic in contextualising the materials (Lesson Observation, 1/8/02) and attempting to encourage experience before explanation (Lesson Observations 7/8/02 and 12/8/02) even though the students were more used to knowing 'why' before they completed the activity. The teacher occasionally reverted to demonstrations when time got short, or she could see a wider comprehension problem.

Ann divided the students randomly into groups giving students team jobs as suggested in the resource material. As they had already started the unit without having roles the students were not very enthusiastic about adopting the roles (Lesson Observation, 7/8/02). Students reported to the Researcher that it seemed that one member of the team was doing all the work (the manager) and the others were watching, however, the Researcher observed the teams worked effectively together and seemed interested in the task (Lesson Observation, 7/8/02). Ann also provided students with an applied, context-based question as a homework assignment. Students were to design a working periscope and explain how it works using diagrams and describe what sort of image is produced. The students were enthusiastic about this project and consequently the starts of several lessons were delayed as students sought to ask about the project (Lesson Observations, 7/8/02 and 9/8/02).

Vignette 1.

Caucus Race – Refraction (Constructed from field notes taken during Lesson observation 15/8/02)

The classroom was set up as a caucus race with different activities set up around the room. The teacher started by giving several everyday examples of refraction, then the students read through the activity and were given a worksheet to complete. The students were then given a limited amount of time to examine each station (ie. beaker of water with a straw and magnified writing under water) and answer the relevant questions. Students were interested and enthused and worked diligently at each station, until moving quickly onto to the next. The race took 15 minutes for the students to complete. Ann then used probing questioning to elicit students' observations made at the stations and asked students to try and explain the phenomena. Unfortunately due to a discussion on homework at the start of the lesson Ann ran out of time to complete the lesson and use the students' explanations to define refraction. This was completed at the beginning of the next lesson with students discussing their findings before the teacher gave a formal definition. When the teacher taught her other group in the following lesson she modified her introduction and this gave her more time to conclude the lesson more thoroughly (Lesson Observation, 15/8/02 11.45am).

Despite these problems this was a very good example of an investigation, with explanation after experience, use of questions to elicit information and the examples contextualised the phenomena. The students were interested and engaged and worked very effectively in their groups.

Ann gained confidence in her questioning of students and probed students' answers to elicit more complex explanations. In the lesson on rays, students completed the activity and then in the next lesson the teacher drew the rays and the lens up on the overhead to demonstrate to the students. She did not then explain why, but used questions to draw out detailed explanations from the students. The depth of some students' knowledge and understanding amazed her (Lesson Observation, 19/8/02). Although Ann was not keen to let different students work at different rates, students were having more input about the direction of the lesson. After one class discussion Ann said that she had not wanted to discuss colour at that point, however, students questions and genuine interest had directed the discussion (Lesson Observation, 15/8/02).

Ann's concern at this point related to assessment, one of the other teachers in the trial, under pressure from her class, produced a multiple choice and short written test on the work completed so far. It was very traditional test in its design with most of the questions being based on basic recall of definitions and laws. Ann's students completed this test and most gained above average results, however, some were unhappy with this as they had not learnt some of the terms in the test and consequently did not achieve higher marks. Students sought to put pressure on Ann to re-shape her teaching to resemble their expectations of more teacher-centred teaching. It would have been very easy for Ann to capitulate and return to teach more traditionally in order to help students learn/recall answers for traditional tests such as this one. Students were pressured to experience success and would have easily returned to passive listening and remembering in order to achieve this. Students worked in groups to review and correct their tests talking over their answers with their peers. Ann discussed with her students, that the end of topic test would be more open-ended and less recall based and she would give her students an opportunity to practice these open-ended questions (Lesson Observation, 28/8/02). Another constraint was the other teachers in the trial. These teachers were more traditional and wanted to maintain the status quo, which worked for them and their students under the traditional teaching-learning and assessment pedagogy. Although these teachers could not control Ann's classroom, they could influence how the classes were to be assessed. As Ann reported after one class, the teachers in the trial held diverging views and consequently consensus was difficult.

Vignette 2

Colour of Light (Constructed from field notes taken during Lesson Observation 28/8/02)

The worksheet constructed by Ann for the work with prisms contained a historical snippet regarding the work of Sir Isaac Newton. Students were given an unfinished quote from his workbook and asked to complete what they thought he would have written after they completed a similar activity in their worksheet (see Worksheet Appendix 5.1). This historical story provided students with a motivating and unique way of relating science to history.

The half way point

In the second interview, Ann reported on her experiences at the professional development (PD), her overall impression of the curriculum resources, and her changing classroom practice. Ann responded very positively to the PD saying "...I love going and seeing and speaking to teachers from other schools" and insightfully added "... in the PD itself I liked the way they actually used the method that they want you to use, they use the method on us so its constantly being reinforced, its constantly being modelled and demonstrated to us" (Interview two, 30/8/02). She found that the PD answered a number of concerns she had such as the acceptability of summing-up with notes at the end of the activity. Ann noted that she would like her staff meeting to run more like the PD with time set for teachers to talk and reflect on current teaching practices and assessment.

With regard to the curriculum resources, Ann felt that they were not sufficient to replace a textbook, lacking extension and homework questions that would meet the 30 minutes per night homework requirement for Year 9 science. She stated "...our kids are very well trained to do homework, to do more consolidation and practice on problems at home" (Interview two, 30/8/02). Ann, however, did like aspects of the materials, reporting

> the parts I really liked were the parts that showed me how to get the kids working on an investigation with self guide questions or approaches to their investigations and then, with the discussion questions at the end, working in their groups to work on the discussion, and then drawing that together at the end.
>
> (Interview two, 30/8/02)

When discussing the changes that Ann had made to the activities, she reported she rewrote many of the activities into worksheet format as she "felt as though the length of time for various activities didn't really fit our 45 minute lessons" and she could "make them more efficient in terms of time, time efficient, like getting the kids to draw around prisms, which is busy work really" and "..I can make up worksheets that make that go quicker" (Interview two, 30/8/02). Ann also reported that when using the star rating of difficulty for the activities, she felt her top level students needed to do the ground work of level one and two stars and were not able to go straight to three star activities. Ann was very aware that she sometimes did not have enough time to complete the activities and have a discussion; she realised how important it was and was attempting to adjust her pedagogy to increase the amount of time for activity and discussion.

She stated she had often in the past determined what the students know before they start the unit, and stated she found this diagnostic assessment very useful. Although she did not use the diagnostic test at the start of the Light module, she used the diagnostic questions in the Energy module and it generated an enthusiastic class discussion. She noted, however, that her top group of students wanted to check in the book for the answers, not wanting to hand in work that could be less than perfect.

Assessment was still a major concern for Ann. In the second interview, she stated that at the end of the semester the students would sit a science exam which would rank them for upper school classes and she was concerned that any change in assessment may impact on students' options in the future (Interview two, 30/8/02). After the exam students are ranked and those at the bottom of the year group do not do prerequisite upper school subjects and consequently this impacts on their future. Ann struggled to merge the different aspects of assessment. Integrating a less rigid assessment framework designed to assess students' conceptual development, with a more rigid ranking assessment to identify extension and prize winning students. This was an area Ann had considered very carefully; she had examined the concerns of all the stakeholders in an effort to formulate a more effective assessment process. She had not been able to solve the perceived problems in the current system, and Ann did not feel the other staff identified this as such a vital concern (Interview two, 30/8/02).

When Ann was asked about her students' interest and enjoyment she reported that some of the students had found it difficult to cope with the changes, seeking more reading and asking "what they had to learn" especially those students in the top class. Ann explained to students and parents, at a parent teacher night, why the trial was being conducted and that teachers were hoping students would achieve a deeper understanding of the concepts rather than superficial learning. She reported parents and students were accepting of the trial once they understood more about the purpose of the CASSP study (Interview two, 30/8/02).

From the discussion in interview two, the overall impression of the Researcher was that Ann had a clear idea of the strategies that were pivotal to the CASSP project and was consciously seeking to utilise these in her classrooms. She explained that she was "getting more comfortable with it and feeling more relaxed" and also that she was "understanding the process a little better now" (Interview two, 30/8/02).

Towards the journey's end

After much discussion the trial teachers decided to finish the Term with an abridged version of the Energy module. This unit was chosen, as it was very open-ended and very different from the Light module. The number of science lessons at the end of Term was shortened by a number of activity days including, Athletics Day, Drama Day and Year 9 Activity Day.

Students seemed more motivated and enthused during the Energy topic, being keen to participate in class discussion, showing their experiences and knowledge. They seemed to have less expectations of the teacher giving them the answers and were no longer so concerned about what would be in the test/exam. It seemed that they were becoming more self-motivated learners, who were more interested in understanding the topic. The Hot Car investigation was extremely motivating and the students enjoyed choosing the variables to test and writing up their reports, which were extremely detailed. Ann commented on the time and effort the students had put into this investigation, which she felt had been completed to a high level. Her only lament was the time it would take her to devise a marking key and mark all the reports. Students went on to choose activities to complete from either the UV or the Chemical Energy sections, and they had to formulate an investigation from the topic provided. Unlike the Hot Car investigation where students were given a scaffolding worksheet with questions to follow based on the 'Working Scientifically' approach to conducting open investigations (Hackling, 1998). Students put together these investigations over a number of lessons, ending with a report to their classmates on their findings, and relating the findings to real life situations (Lesson observations, 12/9/02 and 16/9/02).

In the third interview at the end of the Term Ann seemed more confident and reported that her teaching had changed. She felt she had incorporated more group work and more group and class discussion, where she said she tried to draw the information out of the students, rather than treating them as having no prior knowledge, and she had found this very successful and enjoyed it. In interview three she reported "I feel as though I've been telling them less". Ann had already started reviewing other topics in which she predicted, in time, it would become a habit to use all the strategies, however, reported:

> It's going to involve a bit of work, re-writing worksheets, and I think trying to think about the discussion questions, what discussion questions to put with activities, I think that's going to be the hard part because the quality is very important I think.
>
> (Interview three, 27/9/02)

She seemed a little more confident when discussing assessment, she had found the diagnostic assessment at the beginning of each module had help focus the students and anchor the section into students' everyday experiences. There was, however, a lot of contention about the end of Term assessment for the module; it was written with only a few open ended questions from the web site, the students had to apply their knowledge to their chosen questions. Some of the teachers in the trial were very concerned that this was a fair test. Although some students struggled to interpret and address the questions, the majority seemed to answer the questions to an acceptable depth.

Ann indicated that she thought the students had gained group skills and were more enthusiastic and effective when working not just with their friends but with other students in their class. She said that the students were not very enthusiastic about the unit, because it had totally different expectations for them from their normal units.

She felt the curriculum resources for the unit had been a useful crutch for her and she had enjoyed using them, however, she did feel that she wanted to use the book again in that format. She decided "I will certainly be referring back to it and thinking 'right, this is the way I am going to teach' lens and images and I'll take some of the discussion questions…" (Interview three, 27/9/02). Ann also praised the professional development component of the study, saying she would seek out further PD about teacher pedagogy in order to "be reminded of" the important inquiry strategies.

Finally Ann still reported having concerns about the assessment of the unit, she thought that the shorter open-ended questions were a much better idea however there was still concern about comparability between her class and the other Year 9 classes. This issue was a concern throughout the entire unit for Ann and the other teachers in the trial, and was not resolved. It seemed that although Ann could see the value in more open-ended questions designed to test understanding rather than recall, she seemed to find reassurance in the objectivity of the marking and grading in the more traditional way (Interview three, 27/9/02).

Summary

In summary, Ann worked with dedication and enthusiasm to incorporate the strategies embedded in the CASS Project which she considered valuable and would help her to become a more effective teacher. From the journal above it is clear that Ann's practice changed throughout the study, helping students to participate more actively and be more responsible for their learning. Students seemed, initially, less enthusiastic about the CASSP project, whether as Ann mused it was because they "could not see the bigger picture" (Interview three, 27/9/02) or that when they became more responsible for their own learning they had to participate more actively in their learning. Towards the end of the study, the Researcher perceived students were becoming more focused on the learning in the classroom than on the test looming at the end of the topic.

Time and assessment issues continued to concern Ann, and she remained conflicted by the role of lower school science as either a focus for improved scientific literacy or as a springboard to upper school science education. It would seem that these issues could only be resolved by reform at a departmental level, which will need to involve not only a change in the nature and purpose of assessment, but also a change in the mindset of the staff and parents in the purpose of science education.

Case Study of Amy

Background

Amy was approximately 35 years old and had been teaching science at the school since she graduated from Teacher's College 15 years previously, interrupted only by maternity leave to have her children. Amy lived in a semi-rural area with her husband and two teenager children, with horses and other animals on her property. Amy reported she had always wanted to be a teacher, considering herself a teacher firstly and a teacher of science secondly.

Class

Amy's classes were all upper school biology and human biology, except for her single Year 9 class. This class was in the lower academic stream (Level 2). Students from this class were weaker academically, and consequently were not intending to take science in upper school. Amy was concerned that the "class that are coming with reasonably negative attitude to science" as they had already be pigeon-holed as not able in science. She acknowledged that:

> If you look at the nature of our school they have a lot of parental and peer pressure to go on to do their TEE so they're feeling that they're already 'boxed'. And so they come in with a lot of negative feelings and actually a lot of them spend their time trying to get out of that, which doesn't foster good learning.
>
> (Interview one, 22/7/02)

She felt it would be a challenge to motivate these students because most of them were not interested in science, just trying to get the grades to go into Level 1. Amy reported that they followed the curriculum of the Level 1 students, however, she had greater flexibility to make changes to the curriculum to fit the needs of the students.

Teacher's Beliefs and Concerns

Amy viewed the purpose of lower school science at her school as having a number of purposes, she stated that these included:

> expose the students to a wide range of scientific literature and science concepts, basically so they can go out into society and be literate and able to understand what is going on, to be able to participate and make good judgments.
>
> (Interview one, 22/7/02)

She also recognised, however, that at her school lower school science had another purpose "some preparation for upper school, because the majority of our students do go on to do their TEE and academic achievement at our school is fostered" (Interview one, 22/7/02).

When asked about her picture of ideal science in lower school, Amy stated the most importantly science must capture students' interest, and encourage student to develop an inquiring and open mind. In order to do this Amy felt that students needed to be furnished with skills and tools to be able to question and to work cooperatively in groups. Amy was very aware of students' hopes and aspirations when coming to class, and how this influenced their interest in science. To this end she talked about how she spent time with the class at the beginning of the year finding out what their aspirations were and what they thought a good student in science was like and what they expected from science teacher. She said that she used their answers "to springboard some of my teaching because I find students have a very good idea of what constitutes learning and what makes a good teacher" (Interview one, 22/7/02). Amy recognised that the students wanted to achieve in science, she said "they wanted lots of activities, they wanted to be involved" (Interview one, 22/7/02). Probing students for their input and using their prior knowledge was a skill which Amy felt she used extensively in her classes.

Amy reported she was "a reasonable teacher in that I am fairly, not totally, teacher-directed, but I do try to have a lot of activities and certainly students do lots of experiments and things like that" (Interview one, 22/7/02) and had a number of concerns about her practice. She stated:

> One of the concerns I have is how to develop a classroom environment that allows a lot of inquiry and experimentation to go on, but at the same time keeping everything orderly and controlled, keeping students motivated and working.
>
> (Interview one, 22/7/02)

Another concern for Amy was her limited general knowledge of physics, she acknowledged that having a more open classroom would be more difficult in "as far a letting them explore different areas and being student-centred". With her background in biological science she was much more comfortable letting Biology or Human Biology classes be more open and student-directed (Interview one, 22/7/02).

Other concerns Amy expressed were related to the size of science classes, and the time available for teachers to prepare their classes. She acknowledged that these were limitations to teachers' practice which would be almost impossible to change, and teachers had to teach within these constraints. She seemed to have accepted that a number of these concerns were boundaries that she had to work within rather than seek to change areas which were not within her power to change.

The Journey

<u>The first few weeks</u>

Amy had spent a lot of time in the school holidays preparing for the Energy and Change unit. When she started her first class she provided students with a file in which she had placed the Light module curriculum resources separated from the rest of the book which she retained. Students were to use their own file paper to answer questions and could write on the materials if they wanted. Amy also provided students with a plan of the first half of the Term's lessons, showing when the first test was planned to enable students to know exactly what was happening in the next few weeks and enabling them to come to class prepared for that day's activity. Amy had already decided that she would use the group roles specified in the materials and she had colour coded the students and team jobs so they would know what role they would undertake throughout the Term as well as detailed instructions on the skills for each team job. In a post lesson discussions, Amy reported that these students could be poorly prepared and setting-up the files with the lesson plan hopefully would help them be more organised (Lesson Observation, 24/7/02).

Amy's first class captivated and interested the students in light by contextualising optical gadgets and relating them to everyday items students were familiar with (ie. glasses and the movies). Students examined the optical instruments with interest, talking animatedly to their neighbour (Lesson Observation, 24/7/02), then Amy questioned the students about each object and students were keen to speculate on their function, this demonstrated using explanation following students' experience. The diagnostic questions, which were completed for homework, were used as a stimulus for vigorous discussion of students' prior understanding of light. Amy invited students to amend their ideas during the discussion and over the next few weeks. Amy was very comfortable with her questioning style, she encouraged and supported all students' ideas, and the students responded well and seemed to be familiar with her style however it was clear that students harboured a number of misconceptions about light (Lesson Observation, 25/7/02).

When students formed groups, Amy allocated each student a colour coded team jobs and spent time outlining the group skill to be emphasised that lesson (Lesson Observation, 25/7/02). These skills were split into three areas, team skills (ie. moving into your groups quickly and quietly, and staying in your group), skills that help the group function as a team (ie. use the name of your team mates, praise others, and listen to others without interrupting) and skills that enhance learning (ie. encourage others to participate, and modify your ideas when provided with new information). Amy had spent a lot of time preparing the group materials over the holiday, she admitted after this lesson that the time spent preparing the Energy and Change topic had limited the time available to prepare her other classes (Lesson Observation, 25/7/02). From Amy's worksheet students knew that over the next few weeks they would complete different team jobs and work with different members of the class during activities.

Over the next weeks, Amy provided a number of very motivating activities which contextualised the material and enthused the students, she used their knowledge as the building blocks on which she based her lessons introductions (Lesson Observations, 25/7/02, 29/7/02 and 1/8/02). The activities were set up to be completed by the students over a specified time frame which kept these students on task. After contextualising the topic, tying activities to something students were familiar with, Amy encouraged them to investigate questions set out in the activities themselves. During these investigative activities Amy would talk to each group about what they were doing and their findings, she was exceptionally adroit at extracting their ideas without telling them the answers at that point. Discussions were always designed to come after the activity and although Amy used student answers to explain phenomena as often as she could, she also put together some salient points on the overhead for the students to copy to ensure all students had notes for students to study from.

To help students' complete homework, as required by school policy, Amy often gave students a number of questions after the activity that they had completed to finish for homework. These she used as formative assessment, allowing her to determine how much of the task the students understood. From this information she then decided if she needed to revisit that activity later to help students increase their understanding (Lesson Observations, 29/7/02, 16/8/02 and 21/8/02). Amy had a very refined ability to judge how long activities would take and consequently rarely ran out of time, if she thought an experiment would take too long for a single period she would either ask the students to prepare the activity one lesson and complete it in the next (The Star Activity, Lesson Observation, 1/8/02) or put together a worksheet to help direct and focus students ideas (Lesson Observations, 5/8/02 and 6/8/02). Towards the mid point of the Term Amy set her students a practical test on the skills of using a light box and drawing light rays, this provided Amy with an opportunity to test a number of areas; to see if students were able to use equipment; to examine students understanding of light rays in preparation for the written test; and as a management technique to settle the class after a poor practical lesson the day before (Lesson Observation, 14/8/02).

<u>The half-way point</u>

During the second interview, Amy was asked for her opinions on the professional development, the curriculum resources and the changes to her practice. Amy thought that both the professional development sessions that she had attended were useful and valuable, and she reported that she had enjoyed both.

She thought the curriculum resources were very good in promoting discussion in the classroom, however, reported she would like to see a little more variety in the activities. She identified particular approaches in the materials that she felt were useful in helping her incorporate key CASSP strategies into her teaching; Amy really liked team jobs and skills and wanted to introduce them into all her lower secondary science classes in future years to help improve students' group skills, and she felt the diagnostic items enabled her to probe students prior knowledge more effectively than classroom questioning. She also felt that the materials had served to remind her of "letting them (students) experience what we are going to do, and then explaining it at the end, I think I am more aware of that" (Interview two, 30/802).

Amy stated that she viewed the materials not as a new text book to be adopted completely but more "as a vehicle to guide some of my teaching techniques and perhaps change some of my techniques (Interview two, 30/802). She went on to comment that she felt that a lot of the inquiry strategies in CASSP were not new to her and had been taught at College, she explained that:

> It (this trial) has certainly made me stop and re-evaluate and think about what I'm doing in the classroom and remind myself perhaps the best teaching techniques and not letting myself fall into bad habits
>
> (Interview two, 30/8/02)

In terms of student performance and enjoyment Amy reported "I feel as though they've (students) enjoying it and enjoyed the activities they were doing and learning from it as well" and were "fairly engaged". She noticed the more everyday contextualising she did the more the students wanted to discuss their knowledge with her and the class (Interview two, 30/8/02).

Amy did have one concern related to students' performance on the test at the completion of the light module. The seven short answer questions, from the CASSP web site, required students to demonstrate their understanding rather than the recall and multiple choice questions they were familiar with. Consequently, the students found answering these questions very difficult and even though Amy had warned them to give as detailed answers as possible, many students gave only basic answers and did not gain high marks. The day after the test, Amy had expressed her deep disappointment in the students' poor results after all her hard work that Term (Classroom observation, 20/8/02). After reflection at the second interview, Amy reported that she felt the students' frustration as they attempted the questions. She continued "I was a bit disappointed at my lack of preparation to get them to answer those sorts of questions, and then just hit them with the test" (Interview two, 30/8/02). She felt, however, that the questions had merit and she wanted to incorporate these types of questions into future tests, however, she qualified this by stating that she felt some rote learning especially for her lower ability group was essential in promoting their success.

> I do believe that success helps students to enjoy a subject and it can get difficult after a while to have them intrinsically motivated and sometimes success helps that, but certainly I felt the questions were good, very good, I thought the marking key that came with them was good, helpful.
>
> (Interview two, 30/8/02)

Towards journey's end

After the middle of the Term Amy started the Energy module and promoted group investigations. On the first investigation (Hot Cars), Amy guided the students through step by step using an investigative planner to help students identify variables and plan all aspects of their experiment (Lesson Observations, 2/9/02 and 4/9/02). In the subsequent lessons the students reviewed their plan, made changes and finally completed their experiment using the materials provided. Students then reviewed and discussed their results as a group and then as a class. Finally, they appraised their original conceptions about car and sun, making amendments and additions to their findings. Students enjoyed this guided investigation and this also prepared them for a subsequent investigation that the students were to complete more independently on heat transfer.

Vignette 3

Story Telling (Constructed from field notes taken from Lesson Observations 13/9/02, 18/9/02,and 19/9/02)

Using narratives to set the scene, contextualising and posing real life problems for students to address.

Amy was a very good storyteller, captivating the class and the Researcher with these miniature narratives, which helped to set the scene for an investigation or present a problem for the students to solve. This story related to the investigation on Heat Transfer where the students had to design an experiment to solve a problem.

Amy related the story about her property out in the bush with two horses on it, and how during the winter it would get very cold over night and in the early morning.

Consequently she described how the horses would get very cold over night and would be very unhappy by the morning. She asked the students for some ways the horses could keep warm and they suggested huddling, running around, stables and horse blankets. Amy used the students' answer of horse blankets to talk about the blankets and how the horses wore them and how expensive they were and how her horses had worn out their old ones and now she needed to buy new ones. She reported that there were a number of horse blankets on the market made from different materials and she wanted to know which type of blanket would be most efficient that she should buy to keep her horses the warmest that winter. Students were keen and engaged and interested, wanting to bring the horses to school for the experiment, however, Amy guided them away from that idea and used their ideas to get them thinking about what scientific materials they could use. As they had recently completed a guided investigation they found it easier to consider variables and construct a fair test, although Amy did sit in on each groups discussion to help them clarify their ideas.

During this time, Amy moved away from the CASSP materials and returned to using the school textbook, however, she adapted this material and continued to use all the key inquiry based (CASSP) strategies in her class (Lesson Observations, 11/9/02 and 12/9/02). When asked about transferring the strategies to incorporate into other resources, Amy reported "I think the strategies are easy to transfer, using whatever resources that you have available" (Interview three, 27/9/02). When asked about the curriculum material Amy had decided that she would not use the book as a whole, but she would take sections of it that she thought had been useful and utilise them. When discussing the materials again with Amy, it was clear that unlike others she was focused on the underpinning framework of inquiry based (CASSP) strategies, seeing the materials, PD and PI as vehicles to promote these strategies, but did not consider them in isolation.

Her initial concerns about preparation time for the lessons had been resolved and she had no longer any concerns about teaching the Energy module. She retained her focus on her specific Year 9 class and did not extend her vision to collaborating with the teachers of the wider Year 9 cohort.

Summary

In summary, Amy explored many of the constraints identified in lower school science education, and she had found a balance between the perceived necessity of rote learning and the use of teaching for understanding for her students. She was confident and familiar in her use of the strategies embodied in the CASSP trial, adapting them to move beyond the CASSP resources to encompass other materials. She demonstrated an understanding of the assessment needs of the school administration, parental expectations and the value of formative assessment to help her plot a pathway for students along the learning road, was able to strike a balance between these competing pressures.

In her final comments she said of teaching

> ..I think that teaching's all about evolving and changing all the time and I will take with it (the CASSP Project) what I have enjoyed with what I think has worked and what I think the students have enjoyed and what has worked for them, and I'll take that with me next term.
>
> (Interview three, 29/9/02)

Participative Inquiry Sessions

Besides attending the classes of Ann and Amy through the Term, the Researcher also sought to attend the PI sessions at school. The sessions occurred in two formats in School A; highly formalised sessions facilitated by the project coordinator using the PI questions from the project to guide the discussion, and informal sessions which occurred between teachers in the same staff room between classes and at the end of the day. While it was impossible to attend all the informal PI sessions at the school, those that the Researcher did attend were mainly concerned about procedural issues and activity success, and were between two or more of the teachers in the room at that time. The teachers involved in the informal PI changed depending on who was in the staff room, however one teacher did not participate as she was in the other science staff room.

The more formalised PI was carried out three times during the Term, using relief staff to provide participating staff with at least a single period of 40 minutes for their discussion. The PI discussion was facilitated by the project coordinator who had produced worksheets with PI questions from the CASSP project. Using the questions, teachers' were encouraged to discuss the theory behind inquiry-based learning, the effectiveness of the inquiry (CASSP) strategies and how the teachers were using the materials. The project coordinator was very effective in the use of questioning to draw out teachers' opinions and guiding the discussion preventing it becoming totally orientated around the many technical issues teachers had with the resources (ie. lack of colour, length of activities etc) (PI Session Two 30/8/02). Ann was enthusiastic about having the opportunity to find out about how other teachers were using the resources and strategies. She, however, again expressed her concerns about how slowly her classes were moving through the materials and the lack of reading and extension materials available within the resources to give as homework and for absent students (PI Session One /7/02). Ann as Year 9 Coordinator was also concerned about assessment on a wider scale and making wider ranging changes to assessment in order to free the time constraints. Another teacher (A2) who was participating in the study was extremely negative and reported how unhappy her students were and how she felt that the materials and the approach was not effective in her classroom, this did not change over the length of the trial, in fact later in the program she was asked if she wanted to leave the trial and go back to her previously used resources. She was extremely concerned about teaching as many objectives as possible to increase her accountability to the parents. When it came to designing a common test at the end of the unit, Teacher A2 was unhappy with the test and added in an extra section and spending time ensuring her students were fully prepared.

The only Physics teacher (A1) involved in the trial in School A, reported she found it much easier to make changes to the materials choosing to spend extra time in some areas while leaving what she considered to be non essential materials out. She felt her students had a much better understanding of those areas as well as becoming more motivated by curiosity to find out the answers. In the PI, Amy reported that she found the strategies were valuable and also familiar to her and this had be a relearning process for her, rather than a new learning experience. Amy said she found the PI very informative and interesting to share their points of view, she felt it improved the cohesiveness of the Year 9 teachers which she felt was a positive step (Interview two, 30/8/02). She felt, however, if this occurred with every year group there would be more meeting than the teachers could manage and lose it effectiveness (Interview two, 30/8/02). She also indicated that although the questions were important the process could be better streamlined and consequently would not be so cumbersome (Interview two, 30/8/02). When asked about continuing with the PI Amy reported that this sharing of ideas and collaboration was necessary and could be continued beyond the period of the study (Interviews 2 and 3, 30/8/02 and 29/9/02).

Teachers were also supported by the school administration both in finding time for teachers to meet during class time and also for staff to report their progress to the administration. Teachers participating in the CASSP trial were invited to attend a lunch with the Principal and Deputy Principal to discuss their experiences.

Summary

Both teachers monitored during the trial report being influenced by their experience and content knowledge, admitting that not being physics trained sometimes hindered their activity choice and the level of student-centred investigation in their classroom. The trial teacher that was physics trained reported that it was easier for her to choose important activities and exclude others that she perceived as superfluous.

Assertion 5.1

Teachers' level of expertise in the content area is an area of concern to case study teachers. This impacts on teachers' choice of activity and the extent to which they allow students to direct the learning.

The context of School A had a substantial impact on the implementation and perceived success of the CASSP trial. The school administration demonstrated a keen interest in the CASSP project and valued the participating teachers' experiences and opinions. The teachers and administration of the school, however, were influenced and guided by strong parental and student expectations.

Assertion 5.2

Students and their parents held strong influential views on the purpose of lower secondary science and teaching and learning in the science classroom.

Assertion 5.3

The school administration at School A was influential in supporting teachers' professional learning.

The teachers participating in the CASSP trial deemed the PI at School A effective and valuable. During the PI at School A the influence of teachers by their peers was very evident, especially in the case of A1 who had very strong negative views on the CASSP project and this impacted on the other teachers in the trial. Teacher A1's attempt to highjack and rewrite the end of topic test was an attempt to force the other teachers in the trial to return to their previous teaching format which was how she was still teaching. This struggle demonstrated the importance of assessment at School A and how this had the power to direct the size and shape of the science curricular. The CASSP project sought to remove this driving pressure by reducing the concepts to be covered and restructuring assessment to evaluate students' understanding rather than their recall skills.

Assertion 5.4
At School A the assessment was identified as responsible for driving the curriculum resulting in pressure to cover large amounts of content in a limited timeframe.

Assertion 5.5
Teachers benefited from time set aside in the PI to consider their teaching practice.

Assertion 5.6
Peer influence acts as a powerful force in facilitating or limiting teacher change.

Leadership was also important in the guiding and supporting of teachers during the trial. The project coordinator was extremely diligent in organising and facilitating the PI sessions through out the trial. He organised for participating teachers to have special time set aside with relief provided to enable them to gather to discuss the project. The project leader also provided teachers with a list of questions to guide them during their PI discussions, and was able to negotiate differences in teachers' beliefs and maintain a focused discussion.

CHAPTER 6: CASE STUDY SCHOOL B: TEACHERS PROFESSIONAL LEARNING EXPEDITIONS

Introduction

Case studies were completed for teachers Bob and Beth at School B using the same methodology as used at School A. This Chapter provides background information about the school, its resources and its students. Following this, the case study follows the teachers' progression through the trial, including their beliefs, their concerns and their teaching experiences.

Context

This section provides background information about the school, the science department, resources and the year nine classes to provide a context within which the reader can interpret the teachers' and students' beliefs and behaviours.

The second case study school is a government senior high school in the outer Eastern suburbs of Perth, Western Australia, catering for students between the ages of 12 - 17, in school Years 8-12. Students attend from the surrounding mainly low socioeconomic areas. Contained within these areas, is a substantial Aboriginal community and approximately one sixth of the students attending the school are indigenous. The School also meets the educational needs of a community home for children, which houses students with limited home lives, as well as some rural students who are unable to commute to school every day. The school is also a point for distance education and several science teachers teach individual or groups of students by radio, or by video, who are based hundreds or even thousands of kilometres away. These students do not have specialised teachers in their district schools to enable them to study science past the primary level. The School has a full time police officer, who, with the year coordinators is responsible for regulating truancy and providing key links into programs in the community. The case study teachers are also homeroom teachers who monitor attendance of the students in their homeroom class as well as students' overall development.

The School was built in the late 1950s and early 1960s as a series of three story buildings, with barred windows. All classes open onto quadrangles, where covered walkways house students' lockers. Students spend their breaks on these quadrangles, as well as on the oval where the students play football during lunch times. The science department is split between one end of the school buildings and the other end, and there was a six-minute brisk walk from one science laboratory on the third floor of one square to another laboratory on the ground floor of another building. Consequently four science staff rooms were spread between both areas of the school with three or four staff in each. This layout resulted in some science teachers in the project never having the opportunity to participate in informal participative inquiry (PI) discussion with their colleagues. Due to the layout of the school buildings the staff and technicians carried trays of equipment up or down stairs to classes from the science preparation rooms. One preparation room can only be entered through the back of a science classroom which also provided additional storage for laboratory material proving distracting to the science teachers and class in the room.

Facilities and Resources

The science equipment was well worn and many pieces did not work, work effectively or continuously for science experiments. There was hardly any equipment stored in the science classroom where both Beth and Bob taught. There were, however, a few sets of glassware on a shelf at the front of the room and a class set of safety glasses in a cupboard. This classroom was old and had a number of faults including windows which would not close or lock. According to staff there was recent discussion at the Department of Education and Training District Office regarding the future of the school, consequently no extensive maintenance was to be carried out until it had been decided. The science classroom that Bob and Beth used all the time did not seem to be designed as a science laboratory when it was originally built. The benches around the perimeter of this classroom were too narrow for experimental work, and had limited power points for students to use. The power points were positioned above the side benches, and therefore the power cords had to be stretched from the power point to tables in the centre of the room where students did their practical work. When there were large groups of students moving around the room, this practice was extremely hazardous.

Students did not have their own textbooks but used the class sets that were kept at the side of the classroom. Even when the trial started and students were given their own copy of the CASSP student resource book, they were numbered and stored in the classroom, and distributed at the beginning of each lesson. Beth also collected and kept students' workbooks in which students kept records of their class work. The School provided these workbooks and Beth collected them after lessons so she could monitor students' progress and ensure that they were available for the next lesson. If students were allowed to take their books or CASSP student resource books home with them, they would often fail to bring them to the next class.

Science Department

Due to the location of the science classrooms and staffrooms, the science staff did not meet very often as a group, except for science staff meetings, which were held in the final student-free period on a Wednesday afternoon. The science department comprised 15 teachers supported by two laboratory staff. Three of the science staff were also year coordinators who were responsible for the care (pastoral, disciplinary and attending to high levels of truancy) of a year group of 130-150 students which was very time consuming. The project coordinator was the Head of the Science Department who was a very experienced teacher in his final year of teaching before retirement.

Classes

The school had eight Year 9 science classes who were sorted into levels based on their academic performance in Year 8. Many of these Year 9 classes ran concurrently so there was extreme pressure on the available laboratory equipment.

Case Study of Beth

Background

Beth was approximately 25 years old and had been teaching science for four years, firstly at a country school where she had been the only science teacher and then moving to School B at the beginning of the previous year. She had completed a Bachelor of Science majoring in Human Biology and a Diploma of Education then went to teach in the country. After her country service she came back to Perth to be married and teach at School B. She chose to teach science, as she said she had always been good at science and mathematics, and said "I didn't want to be stuck in a lab permanently because I like people" (Interview One, 27/7/02)

Class

Beth was the Year 10 Year Coordinator and consequently had a reduced teaching load comprising a Year 9 class, an outreach group of students that were taught on-line, and an upper school Human Biology class. Her Year 9 class was set up with special funding to decrease the class size to 14 special needs students this enabled Beth to spend extra time with individuals to reduce behavioural problems and help students with their general literacy and numeracy skills whilst teaching them science. Previously, this group had been totally removed from the main stream and had one special needs teacher for all their core subjects, however, there was not enough funding to continue the scheme, so students attended classes with the specialist subject teachers but remained within their small group.

Beth's Year 9 class comprised of 12 boys and two girls in total, however, due to absenteeism there was always a few students missing. The class was very heterogeneous and included a number of students with various learning concerns; students with ADHD who despite medication had difficulty concentrating, following instructions and constantly wandered the classroom; students who had extremely poor literacy skills and were unable to read the text book or the CASSP resources unaided; and students who had behavioural problems due to abuse at home and consequently were poorly motivated in mainstream classes. One of these emotionally challenged students was a young boy with anger management issues, and therefore, although he was intelligent he was unable to cope in mainstream classes. Finally, the class included a young boy with a brain tumour who as the tumour spread became less and less able to work unaided and started experiencing trouble with even sitting upright in his seat. This student qualified for an aide in the previous Term however there was no remaining funding for this Term.

Teacher's Beliefs and Concerns

In the initial interview, Beth stated she believed that science was about giving students an opportunity to experience the world around them and encourage them to think and question how the world works. She was concerned that, in the past, education had been repetitive and too content orientated, without any depth of understanding, she felt this resulted in little lasting understanding by students (Interview One, 27/7/02). Beth felt that good teaching and learning involved

> lots of interaction between the kids and also between between you and them and two way interaction not just the teacher being the person telling them everything, them telling me things. Activities, you know like getting them to do things rather than just pen and paper in the science classroom.
>
> (Interview One, 27/7/02)

She went on to describe her science classroom as a positive and cooperative environment. Beth felt her ideal class would be a student-centred environment, where the teacher acts as a facilitator, and the learning is contextualised to link concepts to phenomena with which students were familiar (Interview One, 27/7/02). Beth described her unusual Year 9 class of students and how their special needs directed her approach. This class presented a difficult and fairly unique situation for Beth. She was aware of the challenge, commenting:

> ...it's a real mish-mash of a class so it's a really tough class to teach because you never find one way of learning something that works all the time, there's always kids that don't. So if you do written work, let's say a lot of them can't do it properly. If you do activity based, a lot of them have ADHD so trying to keep them on track, so there's constantly challenges in that environment.
>
> (Interview One, 27/7/02)

Beth's primary concerns related to the special needs of her students. She felt she could not directly change the level of literacy of the students in her class and was concerned as this would impact on students' ability to read and make sense of the CASSP materials. She also had concerns about students' lack of motivation and how they needed to be "spoon-fed with information" rather than processing the information, just "getting a worksheet, and filling the worksheet in and going 'I've done it'" (Interview One, 27/7/02). She acknowledged that changing this mindset and moving to a cooperative model would be challenging.

The activities in the students resource book were classified according to their conceptually difficulty, single stars were the least challenging conceptually while the three star activities were the most difficult conceptually, designed to challenge more academically able students. Before she started the unit Beth was already thinking about how to adapt the materials to her class. She indicated that she would start by using the star ratings as a guide, choosing single star activities as being more suited the students' special needs, and then adapt these further should they prove too difficult for her class.

The Journey

The first few weeks

Beth provided each student in the class with a notebook in which to complete all their work, she collected the books at the end of each class and kept the books in her office. In this way she was able to check students were completing work in class as they were asked, and prevent students from forgetting their books. Most students arrived in class with nothing and Beth also provided them with a pencil and eraser. The students' CASSP books were kept in a box at the side of the classroom and each student had their own book that they used each lesson. Beth started her first lesson with an Energy concept map, asking the students to complete their own concept maps in their books (Lesson Observation, 23/7/02). Beth described the lesson as a disaster saying that many of the students had not been able to form very complex links on their maps, and consequently did not have the prior knowledge that she expected. It helped Beth identify students' prior knowledge and beliefs, and this formed a basis on which she could scaffold new concepts.

When students started using the CASSP resources the following lesson, they found it difficult to identify the questions from the text and struggled to produce written answers (Lesson Observation, 24/7/02). Following this, Beth decided to modify the materials by preparing worksheets to help direct students by leaving spaces for answers and often putting instructions and definitions on the worksheets which were stuck into the students' workbook when completed.

It has been difficult to incorporate computer based learning into the science curriculum at School B. As seen in the vignette below, despite vast amounts of preparation, Beth's attempts to use computers in her science classroom failed due to problems with the hardware and software. (Lesson Observation, 30/7/02)

Vignette 1

Technology Lesson (Constructed from field notes taken from Lesson Observation, 30/7/02)

For this lesson Beth had booked the computer laboratories and students were to investigate 'Galvani's experiment from a web site as listed in the CASSP materials. Beth had already checked the web site and noted its suitability. There were about 12 computers

in the class and the laboratory technician had confirmed to Beth that all the computers were operational and had given her the password to log on the students through the server.
Once the students entered the room, Beth asked them to start up the computers, which most students seemed confident to do. Unfortunately several computers were not complete, missing a mouse or a keyboard and several more failed to boot, meaning that several students had to share their computers. These students did not share with others very cooperatively and for the most part Beth had to be very careful if she did pair-up students to avoid fights from breaking out. The students entered their passwords and there was no response. None of the computers, not even the teachers' computer at the front of the room would connect to the server. As the teacher attempted to 'fix' the computers students began to wander around the room, distracting other students and being off-task. The lesson was wasted as the computers never managed to be connected to the server and consequently to the internet. Beth must have expected trouble as she had already managed to down load the relevant pages from the computer several days previously and went to photocopy them so the students could complete the activity on Galvani.

After the first few lessons Beth was keen to discuss her approach to maintaining discipline in her class as this was obviously one of her areas of concern. She said that she tried to be very tough but fair on the students making sure all the students completed each task and stay focused on their work and did not disrupt others. Sometimes she felt her job was just about providing students with a safe and comfortable environment, scaffolding structure and enforcing consistent and fair rules. She said she encouraged students to respect her and each other by respecting them and forming relationships with the students. Several times in later weeks, however, she was forced to eject students for rudeness and these students were sent to another teacher's of an upper school class for the duration of the lesson. Several students were on probation and needed behaviour forms completed at the end of each lesson to satisfy their Year Coordinator, so their behaviour was also a concern in other teachers' lessons. (Lesson Observations, 23/7/02, 25/7/02 and 3/8/02).

Over the next weeks the students worked through worksheets that Beth had constructed from the CASSP Electricity module resources. The increased structure in the worksheets helped the students whose literacy was poor and who struggled to construct sentence answers. Beth found it hard to motivate students and needed to walk around the class to keep them on-task while they completed these initial comprehension type worksheets (Lesson Observation, 30/7/02). Students still found some of the concepts in the Electricity module very complex. At one stage Beth repeated a lesson in a different format after she found from examining their books that the students had not understood the concept underpinning an activity carried out previously (Lesson Observation, 27/7/02). Once the activities became more hands-on and practical in nature (ie. constructing circuits with equipment) students became more engaged and more motivated, wanting to move through the activities to find out how things worked. Beth introduced the concepts relating to the activity after students had completed the activity, and this was often at the start of the following lesson. Theses students were able to concentrate more effectively at the start of the lesson and Beth used the practical component of the next activity at the end of the lesson as a motivator to keep students on task through the conceptual work (Lesson Observations, 6/8/02 and 8/8/02).

Students worked mostly at a self-paced rate in each lesson, with one student finishing the set practical in 15 minutes, while another barely starting the task after 50 minutes. This dramatic difference in rate due to the students' learning challenges was one of the teacher's greatest concerns as the Term progressed, the necessity to find a balance in conceptual difficulty and a rate of movement through activities that suited all the students. Beth used this self-paced approach to her discussions, listening to students' ideas and discussions individually or in small groups, which enabled her to monitor students' progress closely. As students' enthusiasm and motivation increased Beth grouped together some students to encourage them to practice working cooperatively together. She also grouped together students working at different levels, with one student acting as a mentor and helping the other student understand the concepts (Lesson Observation, 8/8/02).

The half way point

In the second interview Beth reported on her experiences at the professional development (PD) and her overall impression of the curriculum resources, and her changing classroom practice. She expressed her enthusiasm for all aspects of the second PD especially the session on assessment, and said she was looking forward to implementing these strategies in to her classroom (Interview Two, 26/8/02). Beth also enjoyed hearing other teachers' experiences, especially the idea that she was not alone and "just also hearing the problems that other people are having, so it feels like you're not the only one having a couple of issues." (Interview Two, 26/8/02).

Beth said she was enjoying using the CASSP resource books, as these books incorporated all the necessary materials for the Energy module. In previous topics Beth explained she had had to compile her own resources from a variety of textbooks. She explained that she was adapting the materials to suit her lower ability group, modifying the materials into worksheets and encouraging students to use the structure and fill in answers, which students found easier to use. She felt that the learning had been more hands-on, reporting:

> ....that more hands-on sort of learning and also then learning before us talking about it has actually worked better for this group. I didn't think it had until I started doing some assessments and things with them and surprisingly they were a lot quicker with it.
>
> (Interview Two, 26/8/02)

She said that modifying the book had been a case of trial and error, after a failure of an activity in class she reviewed the activity and used other materials to teach the concept. Beth said, she felt that her teaching had become more activity-based and contextualised, which had helped students learning. Even though Beth had concerns about students working in groups, she felt she had seen an improvement in a number of students' ability to work together and saw students being more tolerant and respectful of each others' opinions and ideas (Interview Two, 26/8/02).

She still had concerns about making a reasonable rate of progress in the module and meeting the needs of all the students, however, she said:

> I made a decision I think very early on that I would rather cover a minimal amount of work and make sure I cover it in reasonable depth and make sure that the kids understand it than cover half the book and the kids not understand any of it.
>
> (Interview Two, 26/8/02)

As Beth's class was deemed special needs, she did not have the same constraints of having common objectives and assessment tasks as the other teachers teaching Year 9 science, so she was able to decide what aspects of the course to cover.

Towards journey's end

As students progressed further through the Electricity material they seemed more focused on the task at hand, enjoying and interacting together more effectively and there were less off-task instances with the boys in the class, however, the girls did not seem to enjoy the hands-on activities and were off-task more frequently (Lesson Observations, 22/8/02 and 3/9/02). Beth implemented a formative assessment item, the students completed the task, and then the teacher checked each student's work in class, talking through their answers and re-directing their ideas and helping them revise their answers as necessary (Lesson Observation, 3/9/02).

Vignette 2

Sirens and Dog Door Openers (Constructed from field notes taken from Lesson Observations, 1/9/02, 2/9/02, 3/9/02 and 10/9/02)

As the students were enjoying the Electricity activities Beth decided to obtain some simple electronics kits from a local electronics store and students were allowed to construct any activities from the kits. These kits proved to be extremely popular with the boys in the class and Beth was able to use them as motivators and fill in time for students who had completed other work satisfactorily and had it checked by the teacher. Beth was delighted by the students' enthusiastic participation in these projects and that students were more interested in coming in to class, settling down and working harder in order to have time available to work on their projects. In fact, one lesson before lunch, students were so keen to work on their electronics projects that they asked to stay in at lunch and continue their work. Beth was amazed because previously students had only ever stayed in the classroom over lunch as a punishment for misbehaving during the lesson.

After the Electricity module, Beth and the class began work on the Energy module for the final weeks of the topic. The first activity was the Hot Car Investigation, which Beth wanted to use as an assessment item for reports. Students demonstrated an increased level of maturity and were working more effectively, collaborating with other students. Most of the students were able to design and plan the activity, with each group testing a different variable. Then students had to order the equipment they would need in their next lesson to complete the investigation. Beth encouraged the students to be more independent and work with their group members, however, she checked their progress and provided feedback at each stage to keep students on track (Lesson Observation, 10/9/02). The investigation was set in a real life context and students were able to relate it to their own experiences of being in hot cars during summer.

In the end of topic test Beth chose a combination of questions, some from the CASSP assessment web site which were more interpretive in nature and others that were simple objective questions. She felt the wide range of questions would enable her to challenge all the students and determine their achievement of the outcomes. When reviewing the test results, Beth found that some students had only been able to answer one or two very simple questions, however, a couple of students had been able to attempt all the questions and passed the test successfully.

In the final interview Beth said again, how students had really enjoyed having experience of phenomena before explanations, which she called "exploratory type learning" and how she felt that this had been very successful (Interview Three, 27/9/02). Beth said she found the resources effective at providing extra material to extend the more able students in the class. She was still rapt with some of the students' changes in attitude towards coming to science and how keen they were to work on their electronics kits, which she said had been a great motivator. She still felt her students needed more structure than the CASSP student book provided and said that if she could have the book in any format she would choose a workbook format for these lower ability students.

Beth did express concerns about the outcomes and levelling that form part of the assessment structure. Beth reported that outcomes were time consuming and there was still confusion among teachers about judging student levels. These concerns were not relevant to her class in this trial, as her students were less affected by the assessment issues then the more able students, however, in saying that she was still aware of the levels of many of the students in the class. She was enthusiastic about the assessment questions on the web and how these were related to the levels and learning outcomes.

Beth's other concerns related to student behaviour and meeting students' needs, which were her initial concerns when the Researcher and Beth first met. On reflection Beth said she thought that the students "were more intrinsically motivated" and consequently enjoying science more this term (Interview Three, 27/9/02).

Summary

Beth worked with dedication and enthusiasm to incorporate the strategies embedded in the CASSP project into her classroom practice. She considered these strategies to be valuable and helped her to become a more effective teacher. Beth was able to: contextualise the science concepts; identify students' prior knowledge; use discussions and questioning with individuals or small groups; use formative assessment to identify a concept students had not understood, she would then discuss the concept with individual students, or re-do activities with groups or the class; incorporate the strategy of explanation after experience in most aspects of the science; and; over time more students were seen participating in cooperative group work.

Students were observed to respond to a more practically based student-centred approach and from observations were more confident and enthusiastic about science.

Beth was still concerned about her ability to address the special needs of this class in ensuring their emotional and social needs were met. She felt that she was developing them as rounded individuals, improving their social abilities, addressing their basic literacy needs and providing them with useful science. She still had a number of concerns relating to levelling and outcomes in the assessment process and the confusion that still surrounded the necessary judgments about students' levels of achievement. She felt, however, that these were addressed in the Web resources provided in the CASSP trial, although she had not had the opportunity to use them in her classroom. Beth was also concerned as a Biology specialist how her lack of content knowledge of physics impacted on her ability to provide a student-centred environment.

Beth's Year 9 class was a unique group of students and Beth saw her primary role as addressing their emotional needs and providing them with a safe environment where they were accepted and respected. Beth's secondary role was to help improve students' self esteem, and to encourage and motivate students to achieve in science, while keeping their behaviour within the boundaries that she set.

Case Study of Bob

Background

Bob was in his late forties however he had only been teaching four years after completing a Bachelor of Science majoring in Biology, and a Graduate Diploma of Education. Before his degree and his new career in teaching, Bob was a 20-year veteran of the Royal Australian Air Force working in electronics, so he also had an extensive physical science background. He said he was a very poor student at school and "a real smart ass" (Interview One, 22/7/02) and had to complete his Electronic Engineering at TAFE at night school after being expelled from school when he was in Year 10. Bob said "Even though I was a rat bag at school, my career aim was always to be a teacher" and he said that he uses himself as a negative role model telling students there is an easier way to achieve your goals (Interview One, 22/7/02). He commented:

> I'm 48 years old, so relating to kids who are 15 years old is a bit of a stretch sometimes but I've always been good with people, I've been able to develop a rapport with them generally by letting them see me as a person.
>
> (Interview One, 22/7/02)

Class

Bob had a very busy timetable with his classes spread across the school campus. He taught two Year 9 science classes, a Year 9 electronics class, a Year 10 and an upper school biology class. His Year 9 classes were at two different ability levels, one an average ability class, and the other was a higher than average ability class. The Researcher observed the above average Year 9 class, which was a very large class of 32 students.

Teacher's Beliefs and Concerns

Bob described the study as "a breath of fresh air" and taking another look at the teaching and learning of science was good, as he had not reflected on his science teaching (Interview One, 22/7/02).

Bob believed that the purpose of lower school science was to provide students with "a solid science background for general life experiences and to prepare them for post-compulsory studies in Year 11 and 12" (Questionnaire 1, question 1). In his ideal classroom, Bob imagined that there would be different groups of students all completing different activities, then after the activity the students' discuss in their groups and then there would be class discussions of their findings. He wanted students to walk away with a greater understanding of energy and how it is used in the workplace and in everyday situations. Bob wants to give students an opportunity to be self-paced and to contribute to classroom activities and discussion and not driven by him, as he perceives the situation is now.

Bob describes his ideal class as a place where he is only a voyeur, he said "my role would be simply to stand in front and make sure things were done safely" (Interview Two, 30/8/02). He went on to explain:

> ...how I would optimally like them to develop for themselves, would be just to present the problem and let them loose, give them sufficient time to research it, trial it and replicate it to come up with a common sense of understanding themselves without (Bob) having any input at all.
>
> (Interview Two, 30/8/02)

Initially, Bob's major concerns related to the behaviour of the students, and the design of the science classroom. He was concerned that the classroom was small and poorly designed for his large class to complete experiments successfully. The classroom design and the students' poor behaviour resulted in Bob having safety concerns when performing science investigations. He said that he has already said to the students:

> I said to them all alone 'If you guys can't follow a simple instruction like keeping quiet when I ask you to, then I'm not going to trust you to carry out an activity where you have to rely on your own self judgment.
>
> (Interview One, 22/7/02)

The Journey

The first few weeks

Bob started his first lesson late, arriving 15 minutes after the class started, then with the roll to be called and the resources to be numbered and given out, the class was delayed further. Bob used the first section of the lesson to determine students' ideas about Energy using students' concepts to produce a detailed concept map on the blackboard. Bob showed the students he was knowledgeable about Energy, contextualising many of the concepts and using students' knowledge to construct notes on the blackboard. Bob found trying to help students to expand their single word answers challenging, and failed to involve a small number of students in the back of the class to participate (Lesson Observation, 22/7/02).

Over the next few lessons Bob did not use the CASSP resources but gave notes on energy sources that he considered had not been adequately covered in the materials. The lessons were mostly teacher directed, although some students were interested when Bob contextualised the ideas and an interested discussion in the front section of the class ensued (Lesson Observation, 23/7/02). He introduced and gave notes to the students on the important concepts that would be explored in the investigations later in the Term, essentially introducing explanations before activities.

Bob started using the CASSP resources with the Hot Car Investigation from the Energy module. Over several lessons he encouraged students to discuss as a class the factors effecting how quickly a car heats up and gave students the 'Investigation Planner for Science' sheets to help direct their investigations (Lesson Observations, 30/7/02, 31/7/02 and 1/8/02). Impressed by the importance of the investigation process, Bob allocated six lessons to completing the Hot Car Investigation, spending time discussing the ideas of a fair test and use of variables, boxcar designing and types of radiation. Bob did not assign groups but let the students choose their own groups and he did not assign group roles. Unfortunately keeping friends together did not work for many groups, with students either off-task talking and not completing their work or students acting dangerously and showing-off to friends. Bob did not seem to notice much of the off-task behaviour, and this resulted in a number of groups not having any results after all the lessons were completed (Lesson Observations, 30/7/02, 31/7/02,1/8/02, 5/8/02 and 6/8/02).

Bob had a number of other concerns that became obvious in the first few weeks. He was experiencing problems with the technology, the overhead projector did not work and he while he searched nearby classrooms for one that worked, students were noisy and off-task. Bob also had problems being on time to class, arriving very late from his other classes situated around the School, while the waiting students were noisy and distracted other classes. Consequently when Bob did arrive it took him a long time to settle students. Bob had previously stated his concerns about the students' behaviour and did spend a lot of time refocusing students back on task. (Lesson Observations, 23/7/02, 30/7/02, 31/7/02,1/8/02, 5/8/02 and 6/8/02).

As the weeks progressed Bob used a number of investigations from the CASSP Energy module, some students seemed to work effectively in their groups, however, others never settled down to complete the investigations. When Bob contextualised the activities using his extensive knowledge, students were more interested and on task, he encouraged students to participate in group or class discussions with their own ideas, and expressed how surprised he was with what the students already knew about the Energy topic (Lesson Observation,13/8/02). Bob found it very difficult to embrace explanations after experience approach, feeling the need to explain often using theoretical concepts before students started to work on activities.

The halfway point

At the half point in the Term, Bob talked enthusiastically about the CASSP professional development (PD) he had attended. He said he particularly liked the collaborative sessions where teachers talked about the problems they were experiencing with their classes, he said that he was not aware of having any problems he felt that the session was extremely useful in clarifying issues he had not considered. He found the levelling component in the assessment session very useful as he had made similar decisions to the other teachers in his group and was pleased by the consensus.

Bob said that he did not use the teachers' resource book at all, but relied totally on the CASSP student resource book when planning his lessons. He felt that the program was limited in precipitating the extent of student-centred learning he envisaged for his class and he felt he had to teach concepts first because he "...wanted students to know exactly what they are doing and not find out for themselves in case they flounder.." (Interview Two, 30/8/02). He said he felt the classroom was still very teacher directed, although instead of students copying overheads and answering questions from the textbooks, they were using the activities in the student materials. He was able to hold discussions with students either as a class or in groups and try to use students' prior knowledge to form the starting point for the learning. He acknowledged that he had not been successful in implementing the strategy explanation after experiences because he believed that these students would not gain as much out of the activities if they had explanations after activities (Interview Two, 30/8/02).

Bob had chosen to complete his tasks in a unique order and when asked about how he had chosen his pathway of activities he explained:

> I wanted to have a logical progression from talking about, generally, the types of energy and then moving from more general to the specific, so I actually started halfway in where it talked about the six or seven different types of energy and did that first, and then looked at the more specific examples like the hot car experiment as an example of a type and went to other type of energy.
>
> (Interview Two, 30/8/02)

Bob felt that students had been interacting with each other and with him to a greater extent and this was helping students understand the materials. Bob explained that when assessing students, it was important to consider students' written work and their verbal in-class contribution. Bob admitted that due to time pressures in the Term, he had not collected any assessable work from students. Bob hoped that he would start the Electricity module in the next few days, and he was keen to use the diagnostic assessment items with the students (Interview Two, 30/8/02).

Bob expressed many of the same concerns as at the beginning of the trial, he was still trying to work within the physical constrains of a small poorly designed science classroom and found it difficult to set up many of the investigations. He acknowledged that he was unable to change this and was still trying to adapt to work within this constraint. He was also still concerned about students' poor behaviour, and student safety when the students did not behave appropriately when attempting practical work in the classroom. He stated that he had a duty of care to students and cited an example from the week before where students' poor behaviour had caused disruption to his class and other classes around the school.

Bob mentioned outcomes-based assessment as another of his concerns as it took a lot of time and effort to reach consensus within the department about students' levels of achievement in science.

Towards journey's end

Throughout the next remainder of the Term, Bob worked on the Electricity module, however, many lessons were lost due to external factors (ie. Bob went on a three day excursion, Bob was absent, and several whole school assemblies) (Lesson Observations, 4/9/02, 5/9/02, 8/9/02 and 16/9/02)

Bob started the Electricity module by brainstorming student ideas using the diagnostic assessment to determine students' prior knowledge. Bob expanded on his contextualising of information and this proved interesting to a number of the students who also wanted to contribute their knowledge to the class discussion. Bob was enthusiastic in using students' ideas into his discussions, however, failed to curtail the discussion component of the lesson leaving students little or no time to complete the activity component (Lesson Observations, 2/9/02 and 3/9/02). This focus on the preamble of the lesson, sometimes up to 45 minutes of teacher talk, left little or no time for after activity, discussion and conclusions (Lesson Observation, 10/9/02). Bob also included sections of work that he felt were missing from the CASSP materials (ie. static electricity) that were included in the topic's objectives which had remained unaltered from the previous year and consequently appeared in the topic test (Lesson Observation, 17/9/02).

There was a noticeable improvement in student behaviour during the practical activities in the electricity section. These students, mainly boys found the hands-on activities in the Electricity module more engaging and interesting, and Bob had extensive practical knowledge in this area to help students with their activities. Bob was still reluctant to allocate students to groups, saying he felt that students would work more comfortably with their friends. Bob did nominate a student from each group to collect the equipment, which helped reduce the traffic around the room.

In the final discussion Bob said he felt there had been changes in his teaching over the duration of the trial. He acknowledged that he had not moved as far towards student-centred learning as he would have liked, however, he felt the students were participating more in class discussions and copying less notes. Bob was impressed by the depth of knowledge of some of the students and proposed to utilise students' prior knowledge as a platform to introduce learning experiences. He still had concerns about experience before explanation, saying it was a strategy that he felt only worked when the students had some understanding of the underlying concepts, otherwise students are completely unable to navigate their way through activities (Interview Three, 29/9/02).

Bob felt that the Electricity resources were a little basic in their approach at times and he had had to supplement the resources with other materials to cover the School's objectives for the topic. He acknowledged that as this was a National Project there was bound to be differences between any ones schools objectives and the resources. Bob said he had little opportunity to give the students assessment items and as the science department had experienced problems with its computer, he had not had the opportunity to study the assessment resources on the CASSP web site (Interview Three, 29/9/02).

Bob did not feel that the students were becoming more independent learners he said:

> I don't believed they have the self discipline or the motivation to go away and follow up that investigation without me continually checking each step along the way.
>
> (Interview Three, 29/9/02)

Bob explained that he had an unusual viewpoint with regard to his relationship with his students, which was due to his military background. He felt that developing a relationship between teacher and students was extremely important and only through a very strong rapport would students develop a desire to learn. He said he had spent a lot more time this Term with individual students then he did when he used more overhead and blackboard notes, and the students have been able to access him more easily and have been more motivated and interested. Bob said he had enjoyed the project and felt that the majority of the students would have enjoyed the topic, having to take less notes and being encouraged to participate more (Interview Three, 29/9/02).

In his final comments, Bob was still wrestling with his limited resources and his poorly designed classroom, trying to adapt to these constraints proving to be a continual day to day challenge. Student behaviour was also still a concern for Bob as during the Term there had been a number of incidents where poor student behaviour had the potential to cause student injury. These incidents occurred during practical activities and as Bob remarked were due to some students' low levels of maturity; student behaviour would continue to be a concern in Bob's Year 9-science class.

Summary

In summary, Bob felt he had made some changes to his classroom practice to help it become more student-centered. His understanding of a student-centred classroom was one in which the teacher was a passive bystander, rather than a facilitator of learning. Bob did change his teaching role in the classroom becoming less authoritative, engaging in fewer note taking sessions and promoting more group and class discussions. He did adopt the strategies of contextualising scientific concepts, identifying students' prior knowledge, and inquiry-based investigations. Bob retained his beliefs about explanations before experiments and did not make changes to his practice.

Bob held concerns about a number of aspects of the teaching and learning process in his classroom. Management concerns in his science class were not resolved during the CASSP trial and this impeded the learning of some students. He felt there were problems in the supply and maintenance of laboratory resources, and with room restrictions he had to adapt, re-plan and restrict his science investigations. His other concern extended to the assessment. He felt using outcome statements was still complex, time consuming and teachers were having trouble reaching consensus about students' progress and subsequently their level of achievement.

Participative Inquiry Sessions

The participative inquiry sessions were carried out after the general science meetings on a Wednesday afternoon final period. Every department in the school met regularly on a Wednesday afternoon, unless there were other special events organised. The science meetings held in the library, were slow to start as teachers were often late coming from their previous classes. The Head of Department did not use an agenda but held a very informal meeting sharing any recent mail of interest. Then he dismissed the other members of staff, while the Year 9 staff and the laboratory technicians remained. The laboratory technicians had a number of concerns about the equipment and experiments in the CASSP resources to discuss with the teachers and Head of Department. Then the Year 9 teachers were asked 'how they were going' and 'where were they up to in the CASSP resources?', the teachers were not very forthcoming and everyone had very minimal input mainly relating to what activities they had completed. The Head of Department did not seem very familiar with the CASSP study and the aims of the PI sessions even though he had attended the professional development with his staff, he did not use the PI questions and did not seem to even realise that there were any questions. Unfortunately due to many other constraints there were no other formal PI sessions held at School B during the Term, however Beth and Bob both reported to participating in more informal PI in their science staffrooms during the Term. The Researcher witnessed an informal interaction between Beth and another participating teacher, where the other teacher was really excited about the quality of project work her students had produced and this enthused and encouraged Beth. These peer interactions help encourage and support colleagues.

Beth reported:

> ..it was really good just to have three or four other people in the office that were doing the same topic because then we could do it informally, and that was helpful but formal no, we didn't. I meant as for the formal ones it probably wasn't useful because it wasn't done properly.
>
> (Interview Three, 29/9/02)

Bob agreed that the informal PI had been valuable, however when asked about the formalised PI, both concurred what had happened in their department meetings had been a waste of time throughout this trial, however their ideas about future PI were very different. Beth saw a more directed formalised PI as being very useful to her and to other experienced teachers in the department, however, Bob saw the PI mainly useful to graduate beginning teachers who could use "....that sort of guidance from the start and all the way through, would be a lot more effective, would have a lot more benefit" (Interview Three, 29/9/02).

In School B the Head of Department acting as the Project Coordinator did not overtly support and nurture teachers' professional learning throughout the CASSP project. There was no indication that the school administration at School B was aware of the implementation of the CASSP project by teachers in the science department. The case study teachers reported they were disappointed by the lack of support from the Project Coordinator and school Administration, which made them feel undervalued and largely ignored. Teachers reported, however, that the informal participative inquiry was an effective mechanism in improving collegiality between participating science teachers.

Summary

At a school level there was a number of issues that developed over the duration of the trial, these included: the lack of leadership exercised by the Project Coordinator; the lack of overt support from the School administration; the teachers' ability to collaborate together; the abilities and behaviour of the students; the importance of the assessment in driving the current curriculum; and, the case study teachers' entrenched beliefs.

There was a lack of project leadership in school B as the Project Coordinator did not provide teachers with the necessary support to nurture their professional learning. He did not teach a Year 9 science class, did not guide the teachers during the formal PI, support teachers during informal PI, or attend any lessons by the participating teachers.

Assertion 6.1 **Leadership is considered a critical factor in promoting teacher professional learning and change to practice. Without strong and positive modelling and appropriate support from the Head of Department and/or Project coordinator, the change process can be severely limited.**

In school B, the school administration was not overtly supportive of the teachers participating in the CASSP project, this impacted on teachers' confidence and resulted in them feeling undervalued.

Assertion 6.2 **The teachers lacked overt support from the school administration at School B and this may have limited the impact of the change innovation on teachers' professional learning.**

Beth and Bob both expressed concerns about the limited opportunities for peer discussion between colleagues as there were few effective formal PI discussions. Although they did, however, value informal collegial discussions with their colleagues.

Assertion 6.3 **Peer influence acts as a powerful force in facilitating or limiting teacher change.**

Students' ability and behaviour were very influential in shaping teachers' approaches to implementing the Energy module. Although this was the case in all classrooms to a certain degree, it was particularly pertinent to Beth's special needs class. Bob's effectiveness in the classroom was also impacted by the behaviour of his students. As a result many of the CASSP curriculum resources needed to be greatly adapted to meet with the needs of Beth and Bob's students.

Assertion 6.4
The learning needs and behaviour of the students influenced the extent and type of modification to the curriculum resources made by the teachers.

The CASSP project resources were designed to introduce a smaller number of concepts in greater detail to promote increased student understanding. The usual topic test was not reviewed and adapted to match the CASSP curriculum resources and consequently all the objectives included had to be 'covered' by teachers before the test. This diminished teachers' ability to teach for understanding and increased their concern about covering objectives before the test.

Assertion 6.5
At School B the assessment was identified as responsible for driving the curriculum resulting in pressure to cover large amounts of content in a limited timeframe.

Finally, aspects of Bob's practice remained unchanged over the course of the CASSP project. Bob retained strong beliefs that the explanation of a concept was required before the experiment could occur, and this acted as a significant barrier to adopting the constructivist approach. His beliefs were unaltered despite participating in the CASSP trial and using the CASSP resources.

Assertion 6.6
Some of Bob's entrenched beliefs remained unaltered over the course of the CASSP project and as a result there were few changes to his practice.

CHAPTER 7: STUDENT SURVEY AND STUDENT GROUP DISCUSSIONS

Introduction

To develop a comprehensive picture of the impact of the CASSP program, students from each of the Year 9 science classes of the case study teachers, completed a short survey (Appendix 3.4) and selected students from these classes were interviewed in a group discussion. Students were asked to comment on their experiences, the usefulness of what they had learnt, and how much they had enjoyed their science during the CASSP trial.

The 'n' value in the tables below represent the number of responses to each question, in keeping with the approach adopted in Chapter 4 for the teacher questionnaires. Consequently the 'n' value is different for each table. In the case of Tables representing objective responses (Tables 7.1, 7.3, 7.5, 7.7, 7.9, 7.11, 7.12 and 7.14) the 'n' value corresponds to the number of students who completed the survey at that school. In the tables that represent responses to open-ended questions the n value represents the number of responses.

School A

The CASSP project received a mixed response from the students at School A as seen in the results of the student survey displayed in the tables below. Students from School A were asked how they felt about the science and their responses are presented in Tables 7.1 and 7.2.

Table 7.1. School A students' responses to the question: How do you feel about the science you learnt this term? (n= 35)

Response	Count	Percent
Like	6	17
No Feelings	13	37
Dislike	16	46

Forty-six percent of students surveyed reported that they disliked science this term, during the CASSP trial. When asked to elaborate on their answers, only 30% of the students made positive comments about the CASSP project. A summary of students' comments is reported in Table 7.2.

Table 7.2. School A students' comments in response to the question: How do you feel about the science you learnt this term? (n= 48)

Category of responses	Count	Percent
General positive comments – it was fun, interesting	6	13
Enjoyed group and class discussions	1	2
Liked the book resources	2	4
More interesting investigations/activities/ experiments	3	6
Comments about science ie. I like science	1	2
Easier to understand subject	1	2
General negative comments – it was boring, I hated it	9	19
Found student book difficult to understand and interpret, preferred their text book	11	23
Science / physics not interesting or relevant to me	3	6
Learning strategy not effective for me	3	6
Not enough material / needs additional material / did not have enough material to study from.	5	10
Too many investigations	2	4
Irrelevant or no comments	1	2

Students were keen to express their ideas, with 48 responses to the question indicating that many of the students surveyed gave more than one answer. In Table 7.2 a total of 33% of students found specific fault with the student book, with 23% complaining that the materials were difficult to interpret and they preferred their previous textbook, and 10% feeling they needed extra materials added to the student book to enable them to study. This was supported by comments during the student group discussion where much of the discussion focused and refocused on the resources and students reported "...it had all the questions in the boxes but it didn't have any answers", "when you wanted to revise for a test it wasn't very good for revision", "I think the text is harder to understand" (Ann's Class Group Discussion, Amy's Class Group Discussion).

From the discussions it became clear that the students from School A had very definite expectations, not just about the resources but also about all aspects of their learning. Students acknowledged that they were taking less notes and went on to complain "that's why it was so hard to study for the test" (Ann's Class Group Discussion).

When asked about how much they had learnt this term, there was a diverse response reported in Table 7.3 and Table 7.4.

Table 7.3. School A students' responses to the question: How much did you learn from your science lessons this term? (n= 37)

Response	Count	Percent
A lot	11	30
Usual amount	15	40
Little	11	30

Table 7.4. School A students' comments in response to the question: How much did you learn from your science lessons this term? (n= 37)

Response category	Count	Percent
General positive comments ie. I learnt lots	5	14
Group and class discussion increased my understanding	2	5
Resources increased my learning /understanding	2	5
More and more interesting investigations / experiments	1	3
Work easier to do and understand	3	8
General negative comments ie. I didn't learn much	4	11
Classes were confusing and hard to understand	6	16
Found book difficult to understand and interpret	3	8
Not enough material / needed additional material for tests	5	14
No comment or irrelevant answers	6	16

Data in Table 7.3 shows that 30 % of responses indicated that they had learnt less than normal during the CASSP trial, while 30 % indicated they had learnt more. Sixteen percent of responses reported (Table 7.4) that the classes were hard to understand and confusing, for example Student 29 reported "I found my questions weren't actually answered with yes's or no's when asked which confused me." In the group discussion, a student said of the teacher "showing us all the possibilities but then not showing us the answer" (Ann's Class Group Discussion).

Students were also asked to comment on how useful they felt the science was to them this term. The data are tabulated in Table 7.5 and 7.6 below.

Table 7.5. School A students' responses to the question: How useful is the science you learnt this term? (n= 34)

Response	Count	Percent
Very useful	11	32
Ok	14	41
Not much	9	26

Table 7.6. School A students' comments in responses to the question: How useful is the science you learnt this term? (n= 36)

Response category	Count	Percent
General positive comments	6	17
Student understands better	2	5
Student expresses their enjoyment and fun	2	5
Students can see how to apply science to real life	4	11
General negative comments	5	14
Book hard to understand	1	3
Only some small sections were useful	5	15
Already knew information	2	5
Did not understand subject	4	11
Science/physics irrelevant	4	11
No comment/irrelevant comment	2	5

Seventy-three percent of students considered science during the CASSP trial to be 'Very useful' or 'OK'. Fifteen percent of students conceded that small sections of the work was useful, however 11% of all responses said that they thought that science in general and/or physics was irrelevant to them. This idea of the irrelevance of science also appeared in student answers to question one of the student survey displayed in Table 7.2. This was supported by the students' comments during the Group Discussions who said "….. I don't reckon you need to know what refraction is" however, one student conceded "in applying it to real life it's been useful, but not studying it" (Amy's Class Group Discussion, Ann's Class Group Discussion).

In the final question on the student survey, students were asked "In what way has science been different this term?" The results are summarised in Table 7.7 and Table 7.8.

Table 7.7. School A students' responses to the question: In what way has science been different this term? (n= 36)

Response	Count	Percent
Better	8	22
Same	15	42
Not as good	13	36

Table 7.8. School A students' comments to the question: In what way has science been different this term? (n= 44)

Category of responses	Count	Percent
General positive comments ie. it has been better	1	2
Few specific areas were interesting	1	2
Learnt some useful information	2	5
More organised in approach to work	2	5
Group work was fun and enjoyable	2	5
Enjoyed and did more investigations/experiments	8	18
General negative information	6	14
Did not learn well from resources prefer old text	9	20
Need more experiments	1	2
Did not team skills and team jobs	1	2
Need additional material/not enough theory given	6	14
Learning the same	2	5
No comment/ irrelevant comment	3	7

Sixty percent of students (Table 7.7) reported the science during the CASSP trial had been different to their normal science, with 22% reporting it to be 'Better' than previous science, while 36 % felt the science was 'Not As Good'. Many of the CASSP strategies had been identified by the students (Table 7.8), however not all of them had been supported by the students. Eighteen percent of students had enjoyed participating in more investigations and activities, 7 % had identified a change in the format of their group work, however not all these students had supported the changes. With reference to the curriculum resources, 34 % of students had found these different from their normal text and of these 14% had seen that the content was not so highly packed with a reduced number of objectives, but had not supported this change (Table 7.8).

Summary

In summary, the students at School A had acknowledged that the science they had experienced was different and had in question four of the student survey listed many of the differences they had noticed this term participating in the CASSP trial. Although students had not supported many of the changes, feeling that the current system was working well for them. Students reported "we're good at remembering stuff" and "we're not very good at problem solving in our class" (Amy's Class Group Discussion).

It seemed that students had not considered the relevance of their science before and in the interview were more concerned with the perceived deficiencies in the resources that prevented them from getting 'good grades' than the context of the science. When students were asked about the purpose of learning science one student reported the purpose of learning science was "just to learn things and regurgitate them." (Amy's Class Group Discussion). One student wrote on the top of her student survey:

> Questions with no right or wrong answers are useless. Unfortunately in a test, there are right and wrong answers so we need to know what to write to pass. (Student 26 Student Survey)

Assertion 7.1

Sixty percent of School A students identified their science experiences during the CASSP trial as different from normal. Many of the strategies embedded in the trial were identified although not necessarily supported by students (Tables 7.2, 7.3, 7.4).

Assertion 7.2

The students in School A felt that their current system of science education was successful in helping them to attain grades for tertiary entrance (Table 7.8; Student group discussion).

School B

The students from School B were asked in the student survey how they felt about the science they had completed during the term and in the results are presented in Table 7.9 below

Table 7.9. School B students' responses to the question: How do you feel about the science that you learnt this term? (n= 37)

Response	Count	Percent
Like	16	43
No Feelings	13	35
Dislike	8	21

Forty-three percent of students (Table 7.9) responses showed students 'liked' the science that term, with only 21% indicating that they did not like the science. Students were also asked to elaborate on their answers and these categories of responses are presented (Table 7.10) below.

Table 7.10. School B students' comments to the question: How do you feel about the science that you learnt this term? (n= 38)

Category of responses	Count	Percent
General positive comments – it was fun, interesting	7	18
Liked the book resources	1	3
More interesting investigations/activities/ experiments	9	24
Easier to understand subject	2	5
General negative comments – it was boring, I hated it	5	13
Science/ physics not interesting or relevant to me	5	13
More investigations needed	2	5
Irrelevant or no comments	7	18

Twenty-four percent of responses (Table 7.10) indicated they particularly liked the type and increased frequency of investigations, activities and experiments in the course this term. This was supported during the group discussions where students had recognised an increase in practical activities. Students reported "we got to do more experiments" (Bob's Class Student Group Discussion). "We did a lot more practical activities", "last term we didn't do as much projects or hands on work" and "(last term) she pretty much put everything on the blackboard and we had to write it down" (Beth's Class Student Group Discussion).

Students were also asked to comment on how much they learnt in science that term as represented (Table 7.11) below.

Table 7.11. School B students' responses to the question: How much did you learn from your science lessons this term? (n= 38)

Response	Count	Percent
A lot	17	45
Usual amount	16	42
Little	5	13

Forty-five percent of responses (Table 7.11) indicating that they thought they had learnt more science this term than they would have normally, with only 13% feeling that they had learnt less during the CASSP trial.

Subsequently students were asked how useful the science that they learnt was to their everyday life experiences, and are presented in Table 7.12 and Table 7.13.

Table 7.12. School B students' responses to the question: How useful is the science you learnt this term? (n=37)

Response	Count	Percent
Very useful	9	25
Ok	19	50
Not much	9	25

Table 7.13. School B students' comments to the question: How useful is the science you learnt this term? (n= 37)

Response category	Count	Percent
General positive comments	1	3
Student understands better	2	5
Student expresses their enjoyment and fun	1	3
Students can see how to apply science to real life	11	30
General negative comments	3	8
Only some small sections were useful	4	11
Already knew information	2	5
Science/physics irrelevant	3	8
No comment/irrelevant comment	10	27

Twenty-five percent of students responses (Table 7.12) indicated the science was 'Very useful' while 50 % felt it was 'Ok'. Thirty percent of responses (Table 7.13) were able to relate science they had completed to a real-life experience (ie. an electrician replacing fuses in a fuse box). Students in group discussions confirmed they had learnt a lot of practical information that they would be able to apply to real life situations, reporting "So you basically know how a series circuit works now and a parallel circuit" (Beth's Class Student Group Discussion) and "(how) we use electrics and electricity for everything" (Bob's Class Student Group Discussion).

The final question from the student survey sought to examine how science had been different during the CASSP trial, and Tables 7.14 and 7.15 present students' answers.

Table 7.14. School B students' responses to the question: In what way has science been different this term? (n= 36)

Response	Count	Percent
Better	26	72
Same	5	14
Not as good	5	14

Table 7.15. School B students' responses to the question: In what way has science been different this term? (n= 37)

Category of responses	Count	Percent
General positive comments ie. it has been better	8	22
Learnt some useful information	2	5
Enjoyed and did more investigations/experiments	11	30
General negative information	3	8
Learning the same	1	3
No comment/ irrelevant comment	12	32

Overwhelmingly, 72% of student responses (Table 7.14) indicate the students considered the science they participated in during the CASSP project was better than their previous science. Thirty percent of student responses (Table 7.15) again indicated that they had enjoyed the increase in frequency and type of activities and investigations, preferring this type of hands-on experience.

Students in the group discussions reported that they had enjoyed the project with the majority interviewed enjoying the CASSP resources with a student musing "because of the things in the book... like, the questions they had, they explained things better" (Beth's Class Student Group Discussion). Students interviewed, reported they were impressed by the fact they had been provided with new materials, commenting "as long as they are not all ripped and the pages aren't hanging out everywhere like all the other school books" (Bob's Class Student Group Discussion). These concerns extended to their classrooms and laboratory equipment where they reported in unsolicited comments "we need more equipment to do the pracs" and "they have sticky tape holding a broken window together in the gym" (Bob's Class Student Group Discussion).

Summary

Students from School B who participated in the trial gave mainly positive comments about the experience "We were learning about different things, like better things than we were last term" (Bob's Class Student Group Discussion).

Students were supportive of a more investigative hands-on approach to the Energy topic, reporting that they had completed fewer notes this term. They felt that many of the ideas they had learnt were applicable to everyday real life situations.

Assertion 7.3

Eighty-six percent of School B students identified their science experiences during the CASSP trial as different from normal. Many of the strategies embedded in the trial were identified and mainly supported by students (Tables 7.14, 7.15).

Assertion 7.4

Without solicitation, students at School B expressed concerns about the resources available to them and were very aware of the inadequacies in their laboratory equipment and their usual school textbooks, and the state of disrepair of their school buildings (Student group discussion).

Summary

There were vast differences between the two Western Australian case study schools. School A prided itself on preparing its students for the future that for most included University entrance. Students from School A were from mainly wealthy middle class backgrounds with the vast majority focused on their future careers. For the most part students at School A did not enjoy participating in the CASSP trial and felt the material was irrelevant to their lives. They did not like the constructivist learning style that they felt interfered with them identifying and learning the facts to recall at the topic test. At School A only 36% of students surveyed reported that the science during the CASSP project was better than their previous science experiences (Table 7.7).

School B was a local government school drawing its students from low socioeconomic areas, with its major concern being retention of students at school and addressing students' wider social and health needs. Students at School B were focused on their immediate future and many reported they were able to see the usefulness and relevance of science. Many students interviewed at School B reported enjoying the science they had participated in that term, stating it was better than the science they had experienced previously (Table 7.15).

Assertion 7.5 **At School A, only 36 % of students reported that the CASSP project had made science better that term, at School B 74% of students reported the science was better whilst participating in the CASSP project (Tables 7.5, 7.15).**

At School A in the student group discussions, several students could not see the relevance of studying science. On the student survey a small number of students from School A and B reported that science was not relevant to their lives.

Assertion 7.6 **Some students from both schools indicated when surveyed were unable to see the relevance of science to their lives (Table 7.2, 7.6, 7.10, 7.13).**

CHAPTER 8: DISCUSSION

Introduction

The CASSP innovation sought to make changes to the teaching and learning of lower secondary science, by encouraging the incorporation of a number of student-centred and inquiry-based strategies. The effectiveness of the innovation can be evaluated by examining the views and experiences of the teachers and students who participated in the WA trial, and in following the teachers' learning during the trial.

There are three main populations considered in this thesis, these are; the four case-study teachers, the students from the case-study teachers' classes in Schools A and B, identified as students, and the cohort of Western Australian teachers who participated in the CASSP trial including the case-study teachers, subsequently identified as WA teachers. In some sections of this Chapter a fourth population is also considered, all the Australian teachers who participated in the CASSP trial in all States, including the WA teachers, subsequently identified as the Australian teachers. The impact of the CASSP project on these Australian teachers is reported in the *Collaborative Australian Secondary Science Program Pilot Study* by Goodrum, Hackling and Trotter (2003). Where possible in this Chapter, the responses of the Western Australian teachers are examined within the context of the larger Australian population, to highlight the similarities and differences between Western Australian and other Australian teachers participating in the CASSP trial.

This Chapter considers four themes developed from the assertions compiled from the teacher questionnaire data collated in Chapter 4, the Case-study teachers' experiences in Chapters 5 and 6, and the student surveys and the student group discussion data collated in Chapter 7. The assertions carry forward the main conclusions from these results chapters and with the conceptual framework guide and direct the development of the themes.

The first theme, **teachers' beliefs,** seeks to examine teachers' beliefs about effective practice (ideal) and current practice (actual), and the factors which constrain or limit (limiting factors) their practice. The theme also identifies teachers' concerns about their practice, and examines their readiness to change.

The second theme, **teachers' practice during the CASSP innovation**, examines and documents the changes in teachers' practice over the course of the innovation by mapping teachers' concerns, understanding and their use of the innovation (Dlamini et al., 2001; Hall & Hord, 1987).

The third theme, **factors influencing the change process**, identifies and discusses the factors that impact on the change process. This theme seeks to categorise factors into primary and secondary factors, based on their impact on the trial teachers participating in the study.

The fourth theme, **students' views of CASSP**, considers students' responses to the innovation and the impact that students' beliefs and expectations have on changing teachers' practice. Finally the conclusion of this Chapter seeks to draw together the main findings from the research.

Theme One: Teachers' Beliefs

Introduction

It has been acknowledged throughout this thesis that teachers are central to the change process and without considering their beliefs about teaching and learning and gaining insight into their understanding and usage of an innovation, that any new innovation is doomed to fail (Fang, 1996; Pajares, 1992).

This theme is addressed in four sections, the first section **teachers' beliefs about teaching and learning**, identifies teachers' beliefs about ideal teaching and learning and how their actual practice differs from this ideal. This section seeks to explain how teachers can have more than one type of belief and how these beliefs impact on their ability to change their practice. Section two, **constraints that limit teachers' effectiveness in the classroom**, seeks to identify the constraints or limiting factors teachers perceive as limiting the effectiveness of their practice. Section three, **concerns and their impact on teachers' practice**, examines the types of concerns that teachers experience throughout their learning journey. This section acknowledges that concerns change throughout teachers' professional lives, and teachers' ability to change depends in part on their concerns. The final section, **teachers' readiness for change,** examines teachers' motivation and their decision-making process, which weighs-up the costs and benefits of engaging with the innovation.

Teachers' Beliefs about Teaching and Learning

Western Australian teachers completing the questionnaire at the start of the CASSP trial recognised that science is important in enabling students to make sense of the world around them (Assertion 4.1). They indicated that their roles as educators included 'fostering a love', 'helping students to' and 'enabling students' (Chapter 4, Table 4.4) (Figure 8.1).

Assertions

Teachers recognised that lower secondary science is important in helping students make sense of the world around them and this should be its primary role (Assertion 4.1, Chapter 4, Table 4.4).

Teachers identified a large number of attributes of effective teachers. Teachers identified effective students as those who are interested, enthused and motivated to participate (Assertion 4.2 , Chapter 4, Table 4.5, 4.6)

Teachers recognised that their practice was not ideal and they felt they would rather spend more time assessing students' progress and identifying their prior knowledge (Assertion 4.3, Chapter 4, Table 4.7, 4.8, 4.9)

Figure 8.1: Assertions relating to teachers' beliefs about teaching and learning

Western Australian teachers also envisaged themselves as creating environments where students developed a thirst for scientific knowledge and a love for all things science. These sentiments were also shared by the Australian teachers (Goodrum et al., 2003). These ideological beliefs expressed in the questionnaire were elaborated further by the case study teachers in initial interviews. Beth, felt that lower school science should be about giving students experiences about the world around them (Beth, Interview One, 27/7/02) and Ann stated that science should be designed "to satisfy their (students) natural curiosity" (Ann, Interview One, 22/7/02).

The Western Australian teachers also espoused the belief that effective teachers were those that provided inquiry-based learning, contextualised science, facilitated group and class discussions and provided feedback assessment to students to allow them to monitor their own progress (Assertion 4.2, Chapter 4, Table 4.5). Many of the attributes of effective teachers identified by the Western Australian teachers mirrored the skills modelled in the CASSP innovation. There was no single attribute that was identified by teachers as shared by all effective teachers, and this may reflect the complex and multifaceted nature of teaching. Effective students, however, were described in terms of a narrow band of expectations; students' were to enter the classroom self-motivated, be interested, and enthusiastic about science, and actively participate in their lessons (Chapter 4, Table 4.6). These expectations reflected the aspirations of the CASSP project that aimed to engage and enhance students' interest and enthusiasm in science.

In the 'ideal science classroom', teachers felt that students should spend more time on investigations and less time taking notes from the board or overhead projector, with more time in discussion groups and less time working on their own from books compared with their actual teaching (Assertion 4.3, Chapter 4, Table 4.7, 4.8, 4.8). Beth saw her ideal classroom as being one where she was a "facilitator" of the learning, contextualising the learning and linking it to ideas that students are familiar with (Beth, Interview One, 27/7/02). Amy acknowledged a need for balance in lower school science: learning, on the one hand, preparing students for upper school science and external examination requirements; and, on the other hand, ensuring lower secondary science was an entity in its own right and helping students become more scientifically literate (Amy Interview One, 22/7/02). This did not, however, extend to all teachers in the study, case study teacher Bob, when initially interviewed did not have a clearly shaped belief about his 'ideal science' and the teaching he was striving for.

The beliefs teachers expressed in this study about the purpose and nature of lower secondary science were consistent with the current ideology expressed by Millar and Osborne (1998) and identified in the professional standards of the Australian Science Teachers Association (2002), and in *The Status and Quality of Teaching and Learning of Science in Australian Schools* (Goodrum et al., 2001). Keys (2003) identifies three types of beliefs, 'expressed', 'entrenched' and 'manifested' and argues that teachers can hold more than one type of belief. Keys (2003) defines expressed beliefs as those beliefs espoused at interviews but rarely acted upon, while entrenched and manifested beliefs form the foundation of teachers' practice. Keys (2003) organises expressed beliefs into a number of different categories including 'platonic' and 'organisational' beliefs. Platonic beliefs he describes as teachers' ideal views and he argues that teachers are unwilling to make the necessary changes in their practices in order to adopt these beliefs (Keys, 2003). He describes organisational beliefs as those ideological views, which are imposed on the teacher by the organisation, in this case the school and current educational literature, and are seemingly supported by the teacher. Keys (2003) states that when expressed beliefs become entrenched beliefs, teachers' practice will change as the new entrenched beliefs guide teachers' practice. Failure to convert expressed beliefs into entrenched beliefs means they will remain only verbalised and are not translated into practice (Keys, 2003).

Teachers in this study profess beliefs about their practice at interviews and in questionnaires that they acknowledged were very different from their current practice (Cronin-Jones, 1991; Hashweh, 1996; Lumpe et al., 1998a). Keys (2003) theory of expressed and entrenched beliefs is used by this thesis to explain how the teachers participating in the CASSP study hold more than one set of beliefs about teaching. Teachers have beliefs about ideal teaching and learning, which they express at interview, however, these are not currently translated into practice, these are categorised as their expressed beliefs. They also have their actual practice, which is underpinned by another set of beliefs, believed to be entrenched beliefs (Keys, 2003). It is difficult to determine whether these expressed beliefs articulated by teachers, are their own platonic beliefs about the nature of science or if teachers are re-expressing the beliefs of the science education community and their school, organisational beliefs (Keys, 2003).

Figure 8.2 shows how the CASSP innovation provides strategies to help teachers transform their expressed beliefs about ideal teaching into entrenched beliefs which are the foundation of actual practice, thus changing their classroom practice.

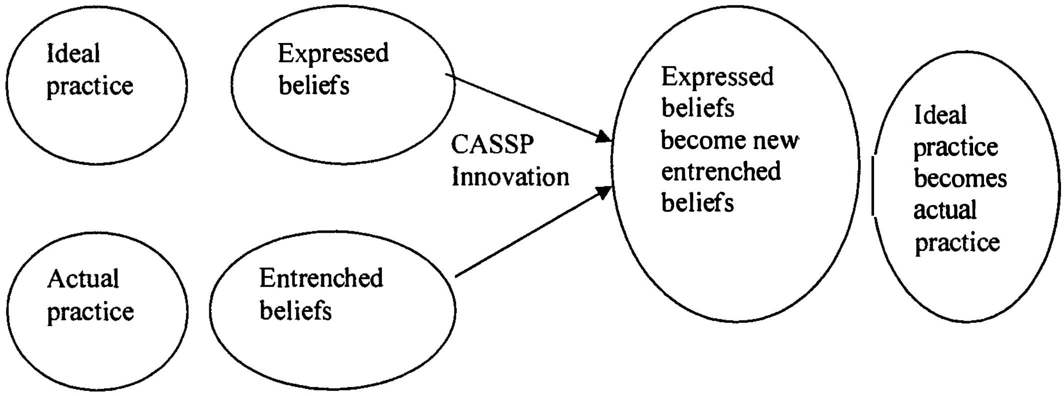

Figure 8.2: A simplified representation showing the proposed action of the CASSP model in converting teachers' expressed beliefs into entrenched beliefs, and their ideal into actual practice.

Original speculation in this thesis suggests that teachers' expressed beliefs would be transformed into entrenched beliefs as in Figure 8.2, so that at the conclusion of the trial some teachers would hold only one set of beliefs, which would more closely resemble teachers' expressed beliefs about ideal practice. Another possible outcome is instead of a transformation where one set of beliefs, the old entrenched beliefs, are discarded and the expressed beliefs become the 'new' entrenched beliefs, there is a re-balancing of the beliefs. Teachers could hold aspects of original entrenched beliefs and incorporate new aspects from the expressed beliefs, achieving a balance between often two opposing sets of beliefs (expressed and entrenched). This could explain Amy's acknowledgement that for her, the purpose of science was to help students become scientifically literate, but this was balanced by the need for students to meet current stringent assessment objectives (Amy Interview One, 22/7/02).

Maintaining the gap between teachers' expressed and entrenched beliefs, and consequently teachers' ideal and actual practice, are those factors that teachers believe are limiting or constraining their practice.

Constraints that Limit Teachers' Effectiveness in the Classroom

The disparity between teachers' beliefs about ideal teaching practice and their actual practice has been created by factors which teachers perceive constrain or limit their practice. Western Australian teachers identified poor student attitude, limited resources and curriculum restrictions as the major factors which they considered constrained their teaching practice (Figure 8.3). The Western Australian teachers, including the case-study teachers, identified a large number of less significant factors as impacting their practice.

Assertions

Teachers identified three major factors which limit their effectiveness in the classroom, these are; poor student attitude, limited science resources and curriculum restrictions (Assertion 4.5, Chapter 4, Table 4.11).

The learning needs and behaviour of students influenced the extent and type of modification to the curriculum resources made by the teachers (Assertion 6.4, Chapter 6).

At School A and B, the assessment was identified as responsible for driving the curriculum resulting in pressure to cover large amounts of content in a limited timeframe (Assertion 5.4, Chapter 5) (Assertion 6.5, Chapter 6).

Figure 8.3: Assertions identifying the limiting factors, which impact on teachers' practice.

Discussion with case-study teachers revealed several other factors which constraint these teachers practice, including poor student behaviour (Assertion 6.4) (Bob, Interview One, 22/7/02), students' lack of literacy skills (Beth, Interview One, 22/7/02) and parents' high expectations about students' learning and achievement (Assertion 5.2) (Amy, Interview One, 22/7/02). The Australian teachers also identified students' poor behaviour (64%) limited science resources (52%) and class size (40%) as major factors impacting on their practice. Other areas highlighted by the Australian teachers included a lack of access to technology, a wide range of student ability, teachers' poor attitude, a lack of parental support, and coordinating a large number of lower secondary science teachers (Goodrum et al., 2003).

Fang (1996) identified these constraints or limiting factors as the 'complexities of classroom life' which he used to explain the inconsistency between teachers' beliefs and their practice. Previous studies by Fang (1996) and Goodrum et al. (2001) identified many of the same factors as those recognised by teachers in this study. Case study teachers, particularly Ann and Beth, expressed concerns that they were trying to reconcile many different expectations in the classroom. A major constraint experienced by Ann was the pressure she felt due to the packed curriculum, which required her to rush from one assessment to the next. She said that this was becoming worse in recent times as the amount of practical work considered necessary to be completed in the curriculum increased and there was no resulting reduction in the number of objectives to be covered (Assertion 5.4) (Ann Interview One, 22/7/02). This curriculum, that was jam packed with objectives that were only able to be covered in minimum depth, resembled the 'inch thick, mile wide' curriculum identified by the National Research Council (2000) in its analysis of American school syllabuses.

Concerns and their Impact on Teachers Practice

The constraints that limited teachers practice lead to teachers experiencing concerns about their practice. The notion of teachers' concerns is not new; Hall and Hord (1987) revealed that teachers entering and progressing through the teaching profession experienced changing concerns. The concerns expressed by the majority of teachers relating to their pedagogical content knowledge, their lack of effective teaching strategies, and lack of content knowledge (Figure 8.4) are considered in **teachers' concerns about pedagogical knowledge**. Case-study teachers expressed concerns that were representative of their level of experience in the teaching profession and are discussed in **teachers' concerns and their professional learning journey**.

Assertions
Teachers expressed a wide range of concerns about their teaching. Their primary concern related to the effectiveness of the teaching and learning strategies used in their classroom (Assertion 4.4, Chapter 4, Table 4.10)
Teachers' level of expertise in the content area is an area of concern to case study teachers. This impacts on teachers' choice of activity and the extent to which they allow students to direct the learning (Assertion 5.1, Chapter 5).

Figure 8.4: Assertions relating to teachers' concerns about their classroom practice

Teachers' concerns about pedagogical content knowledge

Teachers' pedagogical content knowledge, includes teachers' content knowledge as well as the bank of pedagogical strategies they draw on to guide students in their learning. The idea that innovations could be brought and given to the teacher resulting in a 'fool proof' implementation is no longer accepted and a vast amount of teachers' classroom knowledge has been acknowledged and accepted as crucial to the implementation of an innovation (Doyle, 1990). Teachers possess a wide range of classroom knowledge; some of this knowledge includes management skills, subject content knowledge, knowledge of pedagogical strategies, assessment strategies and knowledge of their students. Many teachers in this study questioned their effectiveness in the classroom and if the teaching and learning strategies currently being implemented were effective in developing students' understanding and engagement with their lower school science. Ann was concerned about her current effectiveness in the classroom, musing that having the appropriate strategies would help her translate her ideal beliefs into her classroom practice, however, currently she felt "there's things I had to change and I don't know how to do it" (Ann Interview Two, 30/8/02).

Three of the case study teachers and a small number of the Western Australian teachers expressed concerns about their lack of content knowledge in the physics area. Ann, Amy and Beth were all biological science teachers and therefore, even though they had previously taught the Energy topic, were concerned that their limited knowledge in the subject area would reduce the amount of open-ended activities they were comfortable participating in. Amy said that, having a more open classroom and "letting them explore different areas and being student-centred" would be more difficult (Amy Interview One, 22/7/02).

Teachers' concerns and their professional learning journeys

Teachers listed a large number of other concerns which can be categorised using Hall and Hord's (1987) stages of concern. These included unrelated, self (related to teacher), task (management issues about time, resources) and impact concerns (related to how the task impacts the students learning). Hall and Hord (1987) noted that teachers do not necessarily progress through them in a linear fashion, with new experiences, innovations and other factors impacting on the type and amount of concerns teachers express. Case study teachers Bob and Beth had only a few years of teaching experience, and they experienced self and task concerns. Bob's concerns related to the mechanics of his classroom, including his lack of space and resources and also his students' poor behaviour (Bob, Interview Two, 13/8/02). With Beth's small unique class, her concerns related to her ability to address their special needs effectively (Beth, Interview One, 27/7/02). Ann and Amy were far more experienced teachers, and as Hall and Hord (1987) predicated their concerns were quite different. Amy had very few concerns about her teaching practice, common with a teacher of her experience. Ann, however, expressed impact concerns about her effectiveness in the classroom. She felt her current classroom was "too teacher-centred" and she was often too rushed to have sufficient time to complete the objectives and was concerned that students were not having time to play and experience science (Ann, Interview One, 22/7/02).

The component of the conceptual framework displayed in Figure 8.5, below highlights the relationship between expressed and entrenched beliefs and how they are separated by the constraints that teachers identified as limiting their practice. These constraints create concerns, which must be addressed in order to harness teachers' motivation to adopt the CASSP strategies.

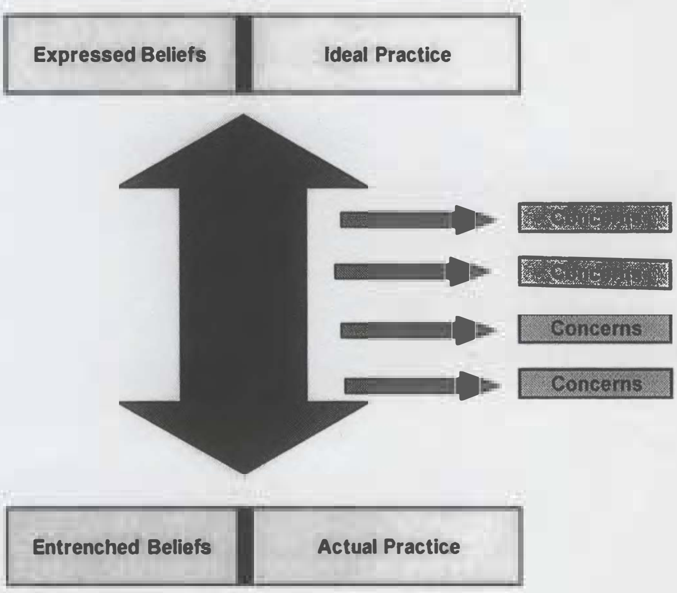

Figure 8.5: Conceptual framework component 1

Teachers' Readiness for Change

Concerns are pivotal to a change process. Without identifying and addressing teachers' concerns, a professional learning program would never have the impetus to create changes in teachers' practice. There is often an assumption that teachers will be supportive of any proposed changes and want to adopt any new innovations. Research in the health field has demonstrated that in order for a person to participate in a change process, they must identify a need to make changes to their behaviour (Prochaska et al., 1994). Prochaska et al. (1994) determined that participants needed to see that making a change would give them significant benefits and these would outweigh the extra work and effort required to make them. They reason, that if the participant decides that the benefit outweighs the extra effort required, then they will seek to make changes (Prochaska et al., 1994). Similarly teachers must consider all the pros and cons of participating in the innovation. Teachers who do not identify a significant benefit of the proposed changes will not actively engage in the innovation, even though they may still participate. Observation revealed a number of teachers in this trial, including A2 at School A, who, having weighed-up the costs and benefits of attempting to make changes to their practice, decided that they did not want to change. These teachers spent the remainder of the trial raising negative aspects of the trial to their colleagues to reinforce their decision (A2, Chapter 5, Participative Inquiry)

It would seem logical to expect this process of weighing-up the costs and benefits to continue throughout the trial and if at any point the costs outweigh the benefits teachers would no longer seek to make changes to their practice. Teachers need to see the value of the proposed change and its impact in the classroom, before they are motivated to leave their comfort zone to attempt to construct a new classroom environment for learning.

In this innovation, teachers needed to see the benefits of the CASSP strategies in improving teaching and learning. The trial sought to help teachers reflect on their practice by contrasting their actual practice and their ideal practice. This reflection would help teachers decide that there would be value in adopting new practices and consequently would attempt to make changes to their teaching practice. Teachers, such as Bob were far more preoccupied with their immediate classroom management concerns and were therefore less likely to have strong concerns about making changes to their practice. As a consequence, Bob committed very little time and energy to the CASSP trial, as most of his time and energy was diverted to attending to his classroom realities (Doyle, 1979). It is speculated that Bob may not have used the trial material so diligently if he was not under observation as part of this research project.

A second component of the conceptual framework illustrated in Figure 8.6 shows the cost benefit analysis that this study predicts teachers will engage with before and during the implementation of the CASSP strategies. The arrows show that the analysis occurs throughout the professional learning program.

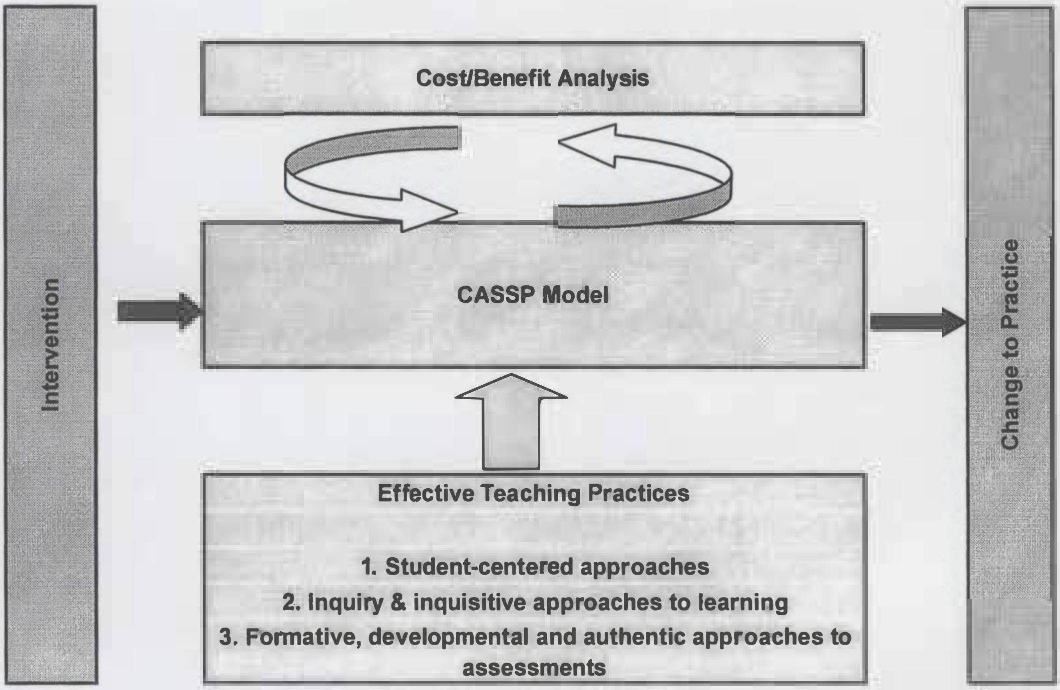

Figure 8.6: Conceptual framework component 2

Summary

- Teachers' expressed beliefs about the purpose of science teaching, and ideal teaching and learning mirrored the ideological beliefs espoused by current leaders in science teaching research. Prior to the innovation these beliefs, however, were not translated into practice due to perceived constraints.
- At the beginning of the innovation, many teachers in the study were aware that their current practice was different from their beliefs about ideal classroom practice. This gap between ideal and actual classroom practice created concerns for

some more experienced teachers (e.g. Ann). Younger less experienced teachers (Bob and Beth) had different concerns compared to more experienced teachers, their concerns related to the management aspects of their class and were identified as mainly self and task concerns.

- Teachers' lack of pedagogical knowledge was most commonly cited as the most important factor limiting their teaching, however, three of the case study teachers reported that a lack of content knowledge also impacted on their classroom practice.
- Before and during the innovation teachers appeared to weigh-up the pros and cons associated with the change process. Teachers become motivated to participate in the innovation, when they recognised that the anticipated benefits outweighed the extra effort required.

Theme Two: Teachers' Practice during the CASSP Innovation

This theme considers the changes that occurred in teachers' practice as they participated in the CASSP innovation. The theme is divided into two sections, the first, **case study teachers' concerns, understanding and utilisation of the CASSP strategies** follows the case study teachers' learning journeys seeking to identify the concerns, processes and incidents that teachers experienced when they participated in the innovation. The second section of this theme, **Western Australian teachers' implementation of the CASSP strategies** is divided into two components. The first component examines the Western Australian teachers' initial thoughts about the CASSP strategies before the innovation. The second component examines teachers' thoughts and experiences after the implementation of the CASSP innovation, comparing it with the experiences of the Australian trial teachers (Goodrum et al., 2003).

Case Study Teachers' Concerns, Understanding and Utilisation of the CASSP Strategies

This section examines each of the four case-study teachers individually and allows the Researcher to build-up a picture of the teachers' concerns about the CASSP strategies, the teachers' understanding of the CASSP strategies and their implementation of the strategies.

Three models have been used to analyse the changes in teachers' concerns about the innovation, their understanding of the innovation, and their levels of use of the innovation. Hall and Hord's (1987) stages of concern have been used to map case study teachers' concerns during the CASSP innovation. Hall and Hord's (1987) stages of concern are illustrated in Table 8.1.

Table 8.1 Stages of concerns (Hall & Hord, 1987) hierarchy of understanding and typology of utilisation (Dlamini et al., 2001)

Stages of Concerns (Hall & Hord, 1987)	Hierarchy of Understanding (Dlamini et al., 2001)	Typology of Utilisation (Dlamini et al., 2001)
Awareness – teacher has no concerns about the innovation	Unawareness – teacher is unable to perceive differences in approach between the ideal practice and current practice	Drop-out – teacher who does not continue to use the strategies after the first attempt
Informational – teacher seeks information about the innovation but are unconcerned about how it impacts on them	Perception – teacher is able to recognise the differences in approach, between ideal and current practice	Struggler – teacher continues to use the innovation but at a very mechanical level, making few changes and with a low level of understanding
Personal – teacher has concerns about how the innovation will impact on them, and whether they will be able to meet the necessary criteria	Utilisation – teacher is able to appropriately describe the use of the strategies in the trial.	Domesticator – teacher who has taught successful lessons using the materials but adapted the strategies to their normal approach to teaching
Management – teacher focuses on the processes and tasks associated with running the innovation	Personalisation – teacher is able to apply the new strategies to their personal teaching style.	Succeeders – teacher has successfully used the approach with understanding but not enough to be independent of the curriculum materials
Consequence – attention of the teacher is focused on impact of the innovation on students.	Production – teacher is able to synthesise and develop contextualised lessons incorporating the new strategies	Innovators – teacher who understands the approach and are able to vary and generalise it to their other teaching.
Collaboration – teacher focus on coordinating with other teachers		
Refocusing – teacher extends the boundaries of the innovation and adapts it		

In order to use an innovation, teachers have to first understand it. It is important then to establish if teachers do in fact understand the innovation and the underpinning strategies. Dlamini et al.'s (2001) devised a five stage hierarchy of understanding that was used to examine the ability of the case study teachers to differentiate between their current practice and the strategies advocated in the CASSP approach (Table 8.1). Dlamini et al. (2001) also developed a typology of use based on Hall and Hord's (1987) levels of use, producing a hierarchy which was used to classify the teachers' use of the innovation (Table 8.1).

Case-study Teacher Bob

At the beginning of the trial, Bob's concerns were focused on the day to day running of his classroom, according to Hall and Hord (1987) he was at the **awareness** stage of concerns. Throughout the innovation he seemed only marginally aware of a few of the strategies in the trial. He seemed to be unaware of the use of formative assessment and of providing explanations after experience, and had no idea of the structure of a student-centred classroom. In Interview Two, he indicated that a successfully working classroom would only require a marginalised teacher presence. "In an ideal sense my role would be simply to stand at the front and ensure things are done safely" (Bob, Interview Two, 17/8/02). According to Dlamini et al.'s (2001) levels of understanding, Bob was between **unawareness** and a **perception** level of understanding. He was able to identify some of the CASSP strategies, (perception level) however; he failed to recognise other CASSP strategies that were embedded in the curriculum materials (unawareness level).

At the conclusion of the study, Bob was still passive in his participation in the trial, at no time did he seek out information about the innovation and never reflected on his practice until asked to do so during interviews as part of the study. It often seemed that Bob was unaware and had little understanding of the purpose of the resources and the embedded strategies. This is illustrated in Interview Two, when he said "if I thought that the student guide (student resource book) needed more direction then I've tried to have more discussion beforehand" thus precipitating explanation before experience while the resources were designed to provide students with the experience of a phenomenon before explanation. He was not supportive of the student-centred approach and felt that students were not benefiting from the trial, stating "I see a lot of restrictions that limits the program a hell of a lot doing that so much from a student-centred point of view the kids don't learn anywhere near as much" (Bob, Interview Two, 17/8/02). Bob did use some strategies very successfully in his classroom and the students did note that he moved away from giving notes and began to ask students to provide input in class discussions and acknowledged the power of students' prior knowledge. In terms of Dlamini et al.'s (2001) levels of utilisation, Bob was a **struggler**, as in many instances he demonstrated little discernable understanding of the strategies, this consequently limited his ability to implement them. He was aware that his teaching that term was different, however, was unable in many instances to identify the purpose of the strategy. Bob maintained some of his entrenched beliefs, particularly with regard to explanation before experiment and he never changed this aspect of his practice.

Assertion **Some of Bob's entrenched beliefs remained unaltered over the course of the CASSP project and as a result there were few changes to his practice (Assertion 6.6, Chapter 6).**

Figure 8.7: Assertion relating to Bob' beliefs about the CASSP strategies

Doyle (1979) identified multidimensionality, simultaneity, immediacy, unpredictability and history as skill areas in which teachers needed to be proficient to enable them to increase students' task involvement. He stated teachers needed to be able to attend to more than one task at a time (multidimensionality), to concentrate on different ideas at the same time (simultaneity) and to stay alert to the ever changing nature (immediacy and unpredictability) of the class room. The more student-centred and self-directed approach advocated by the CASSP strategies, required teachers to be very efficient at utilising these skills in the classroom. Bob found it difficult to implement the CASSP strategies as he lacked the expertise in implementing these skills to control his classroom environment (Doyle, 1979).

Case-study Teacher Ann

Ann was aware of her teaching practice and her concerns about her classroom practice. In terms of Hall and Hord's (1987) stages of concerns, at the beginning of the trial she expressed **informational** concerns about the mechanisms of the innovation and these quickly became **personal** concerns as she sought to determine how the innovation would impact on her teaching, ie. how to reduce the amount of time she spent demonstrating in her classroom (Lesson Observation, 25/702). Ann was very concerned about her teaching practice and trying to be a more effective teacher in the classroom. At the second interview, Ann was experiencing **management** concerns and was experiencing trouble organising her class time, often starting but being unable to complete an activity within the lesson. These concerns continued throughout the second half of the trial when she sought to construct worksheets to speed-up the activities in class (Lesson Observation, 30/7/02). Ann struggled initially with the time available to cover all aspects of the topic, and was stressed about making judgments regarding which material to exclude from the topic that year.

Ann was very aware, even from the beginning of the trial, of the differences between her teaching and that advocated by the CASSP program and consequently was at the **perception** level of understanding. Later during the innovation she was able to describe the innovation and the new strategies in more detail, outlining where these strategies were demonstrated in her teaching, moving through the hierarchy to **utilisation**.

Ann was aware of the strategies and was careful in planning the learning sequence for her students. She succeeded in helping students' to take more control of their learning (Lesson Observation, 30/7/02), and extended the time available for group activities from five minutes to 35 minutes in some lessons (Lesson Observation, 30/7/02). Ann contextualised the materials (Lesson Observation, 1/8/02) and attempted to encourage experience before explanation (Lesson Observations 7/8/02 and 12/8/02) even though the students were more used to knowing 'why' before they completed the activity. She felt she was able to spend more time discussing students' ideas with them in small groups, asking them for their ideas and the theory underlining them. In terms of Dlamini et al. (2001), Ann was a **succeeder**, using the materials with understanding, however, she found it very difficult to continue using the strategies towards the end of term independent of the CASSP materials.

Case-study Teacher Beth

Beth started the module with strong concerns about her class and their special needs demonstrating an **unawareness** stage of concern about the CASSP strategies at that point (Interview One, 27/7/02). As Beth began to seek information about the innovation her level of concern progressed to **informational** and during the term as she sought to determine how she could incorporate these strategies into her teaching practice she reached the **personal** stage of concern. Beth expressed concerns about adapting the course for her special needs group. She demonstrated both **management** concerns about the task and **consequence** concerns relating to the impact of the strategies on her class of students when she was adapting the material to meet the needs of her students and monitoring their feedback and reactions. From the beginning, Beth was aware of the strategies and how they were different from a more traditional lesson demonstrating **perception** understandings (Dlamini et al., 2001). At the end of term she demonstrated **utilisation** understanding when she identified which aspects of the lessons reflected the CASSP strategies, and discussed how students had reacted to these strategies.

Beth worked with dedication and enthusiasm to incorporate the strategies embedded in the CASSP trial into her classroom practice. She considered these strategies to be valuable and helped her to become a more effective teacher. She set out to use the materials as written in the student resources, however, found that many of her students lacked the reading and comprehension skills to complete the tasks. Consequently, she adapted the materials to the skill level of her students and planned pathways for different members of the class as there was a wide range of abilities in the class (Lesson Observation, 24/7/02; Lesson Observation, 30/7/02; Lesson Observation, 27/7/02). She increased students' motivation by incorporating practical sessions which students could only participate once they had completed their work to a satisfactory level (Lesson Observations, 6/8/02 and 8/8/02). Beth was very comfortable adapting the materials to suit the students' level of expertise and consequently was a **succeeder** according to Dlamini et al.'s (2001) hierarchy of utilisation. As the Researcher did not witness Beth move away from the materials, it is not known if she would have been able to make the transition away from the material and generalise the strategies to her other science subjects.

Case-study Teacher Amy

It was clear from the beginning, that Amy was already very familiar with the CASSP strategies. During the initial interview she stated that students needed to be more independent and able to work cooperatively in groups and she needed to know students' prior knowledge before starting a topic (Interview One, 22/7/02). Due to her familiarity Amy had few concerns at the start of the innovation, these were mostly relating to the logistics of the innovation, which were new to her. These **management** concerns quickly gave way to **consequence** or **impact** concerns, where Amy was concerned about the impact of the project on students' learning. Although Amy was reluctant to talk about her teaching with her peers and would discuss it only when asked, she was very much aware of the wider implications both for the teachers and the students at School A (Interview One, 22/7/02; Participative Inquiry Session Two 30/8/02). Consequently Amy had an excellent understanding of the strategies that underpinned the CASSP trial. She initially followed the book very carefully, as she believed she was trialling the materials, however after the second professional development session she realised that she was not limited to use the materials in the form supplied. By the end of the topic had moved away from the materials and begun to synthesis her own lessons using the CASSP strategies and the school text book (Lesson Observations, 11/9/02 and 12/9/02). When asked about incorporating the strategies into other resources, Amy reported "I think the strategies are easy to transfer, using whatever resources that you have available" (Interview Three, 27/9/02). Amy clearly demonstrated the highest level of understanding of the CASSP innovation, **production,** by developing her own lessons, which ensured true ownership of the teaching approach.

Research by Dlamini et al. (2001) found that teachers with a high level of understanding of the approach and the strategies also demonstrated a high level of use of the approach. This was demonstrated in Amy's case; she was able to vary and generalise the approach to other teaching areas and consequently was considered an **innovator** (Dlamini et al., 2001). Amy's focus was not on the materials as many of her peers, her focus was on the underpinning framework of inquiry-based (CASSP) strategies. She saw past the materials, professional development and participative inquiry, seeing them as vehicles to promote the strategies.

Table 8.2. Case study teachers' levels of concerns, understanding and utilisation

Teacher	Concerns (Hall & Hord, 1987)	Understanding (Dlamini et al., 2001)	Utilisation (Dlamini et al., 2001)
Ann	Informational → Personal → Management	Perception → Utilisation	Succeeder
Amy	Management → Consequence	Production	Innovator
Beth	Informational → Personal → Management → Consequence	Perception → Utilisation	Succeeder
Bob	Awareness	Unawareness/Perception	Struggler

Note. Arrows represent the teachers' progression from one level to another.

In Table 8.2, the case study teachers' progress through the innovation is summarised. A link can be seen between teachers' concerns and their use of the strategies. Teachers with low level of concerns also have a low utilisation of the CASSP strategies. This was the case for Bob, whose concerns were directed away from innovation and towards class management, and consequently his level of use of the innovation was corresponding low. Table 8.5 also illustrates that Dlamini et al.'s (2001) levels of understanding and utilisation are linked; teachers who only had a limited understanding of the CASSP innovation correspondingly only utilised the innovation at the lowest levels (e.g. Bob) whilst teachers who had high level of understanding had high levels of utilisation (e.g. Amy). The relationships forged between concerns, understanding and utilisation are illustrated in Figure 8.8 below.

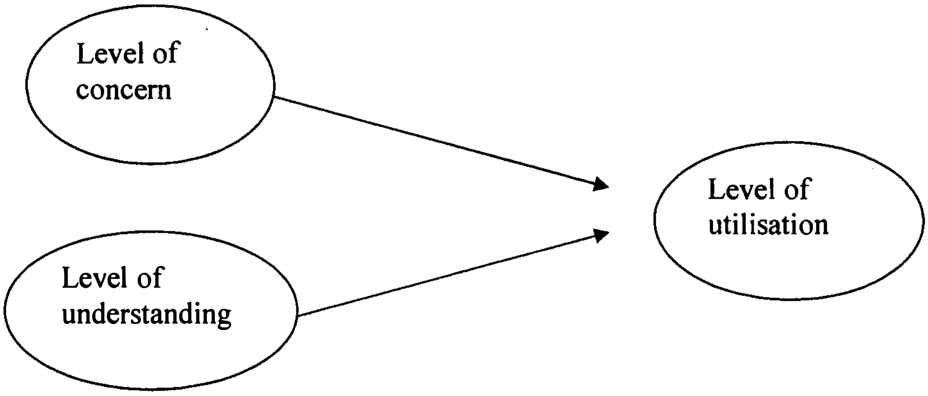

Figure 8.8: The relationship between levels of concerns, understanding and utilisation.

Western Australian Teachers Implementation of the CASSP Strategies

This section analyses the Western Australian teachers' experiences with the CASSP innovation based on the results of the questionnaires they completed throughout the trial. The section is divided into two components, the first addressing the teachers initial concerns about CASSP, and the second their final concerns after they had participated in the innovation

Teachers' thoughts about CASSP before the innovation

The majority of the Western Australian teachers were very supportive of the strategies underpinning the CASSP trial and some were already familiar with them. Amy said that the strategies were very familiar to her and the innovation reminded her about the importance of these strategies in her teaching practice (Participative inquiry session, 21/8/02). Western Australian teachers admitted they had some concerns about the implementation of the strategies. These concerns mostly related to how the teachers would find the relevant resources (ie. material to contextualise the learning), and how this would impact on their practice (ie. time and student management). Hall and Hord (1987) classified these concerns relating to the teacher as self concerns and those related to the task as task concerns. These were the expected concerns for teachers faced with a new innovation (Hall & Hord, 1987) (Figure 8.9).

Assertion

The Australian teachers were also overwhelmingly supportive of the intended CASSP strategies although they also expressed a number of concerns that needed to be addressed before they could be implemented

(Assertion 4.6 Chapter 4, Tables 4.12, 4.13, 4.14, 4.15, 4.16, 4.17, 4.18).

Figure 8.9: Assertion relating to teachers' beliefs about the CASSP strategies

The Australian teachers were also overwhelmingly supportive of the intended CASSP strategies although they also expressed a number of concerns. These concerns related to the implementation of the strategies into the classroom, rather than to the underpinning inquiry-based constructivist teaching and learning theory. The major concerns related to finding a meaningful context for the learning (34%) and also the time to implement formative assessment (48%).

Many of the Western Australian teachers were not familiar with formative assessment as 16% of teachers responses indicated they did not understand this term.

Teachers' thoughts about CASSP after the innovation

The majority of the Western Australian teachers reported on the questionnaire that they had made changes to their classroom practice due to the CASSP innovation, and had benefited from being involved in the trial (Figure 8.10).

Assertions

The majority of teacher (91%) reported changes to their classroom practice with the most common changes being: increase in group work/practicals/discussion (32%); increased use of other inquiry strategies (23%) and increased student-centred learning (13%). (Assertion 4.8, Chapter 4, Table 4.36)

Eighty five percent of teachers reported benefiting from the CASSP trial. The major benefits reported were: increased focus on teaching and learning (36%); and, a greater understanding of CASSP strategies (31%) (Assertion 4.9, Chapter 4, Table 4.37).

Figure 8.10 The assertions formulated about the changes to teachers practice experienced by the Western Australian teacher cohort.

After the innovation the majority of WA teacher (91%) reported changes to their practice. These changes included an increase in the use of the CASSP strategies, including group work/practicals/discussion (23%), student-centred learning (13%) and other inquiry strategies (23%). (Assertion 4.8, Chapter 4, Table 4.36). When compared to the results for Australian teachers participating in CASSP, the national sample reported a stronger increase in group work (42%) and more student-centred learning (32%) than the Western Australian teachers (Goodrum et al., 2003).

The Western Australian teachers were also asked about adapting and selecting activities from the curriculum to cater for students' needs. Initially, most teachers were using the materials exactly as they were presented in the student resource book, with only 20% adapting the materials to suit their students' needs. By the conclusion of the trial, there was an increase to 30% of teachers adapting the materials but teachers still expressed concerns relating to student behaviour, a lack of equipment and resources. Over the course of the trial teachers developed more confidence to modify the materials to meet their needs and the needs of their students, however, some teachers were still bounded by many of the constraints they identified at the start of the trial. Adapting and modifying materials is indicative of teachers' deeper level of understanding of the approaches and resources.

Eight-five percent of Western Australian teachers reported benefits to their practice with the major benefits being an increased focus on teaching and learning (36%), and a greater understanding of CASSP strategies (31%) (Assertion 4.9, Chapter 4, Table 4.37). These findings were similar to those for the national sample. Of the Australian teachers, 49 % reported an increased focus on teaching and learning and 49 % gained a greater understanding of new teaching strategies during the trial. The majority of the Australian teachers (89%) felt that the project should be extended and 88% felt that the resources should be developed to cover other areas of the lower secondary science curriculum.

Long Term Benefits of the CASSP Trial

Evaluating the long-term effects of the CASSP project on the Western Australian teachers was not carried out in this trial, however, the Researcher did contact the case study teachers 12 months after the trial. These teachers all reported that they were not teaching Year 9 classes that year and consequently would not get an opportunity to use the curriculum resources again. This was disappointing, because as reported, change takes time and it may not be until the teachers use the resources further that they feel comfortable with the new practices and these subsequently become embedded in the range of teaching strategies that the teachers have at their disposal (Hall & Hord, 1987; Hewson & Hewson, 1984; Loucks-Horsley et al., 1998).

Summary

- The case study teachers showed a wide range of concerns over the term of the innovation. The more experienced teacher, Amy, had a few mostly high level concerns (**Consequence**) and reached the highest levels of understanding (**Production**) and utilisation of the innovation (**Innovator**). The teacher with least experience, Bob had a large number of concerns relating to issues about his classroom management but not directly related to the innovation (**Awareness**). He demonstrated the lowest level of understanding (**Unawareness/ Perception**) and as a result demonstrated the lowest level of utilisation (**Struggler**) of the strategies of all the case study teachers. Ann and Beth both reported concerns relating to the innovation with Beth reaching a higher level (**Consequence**) than Ann (**Management**), however, they progressed through several levels to demonstrate competent levels of understanding (**Perception to utilisation**) of the innovation and consequently achieved a competent level of use (**Succeeder**).
- A detailed analysis of the case study teachers' level of concern, understanding and utilisation of the strategies revealed that high levels of concerns and understanding are necessary for high levels of utilisation.
- The majority of the Western Australian teachers reported changes to their practice as a result of the study. Towards the end of the study teachers were more inclined to take ownership of the materials and use more student-centred strategies. More teachers adapted the materials to suit their students' abilities, and during the later stages of the trial, encouraged students to choose activities and progress at their own rate. This demonstrated an increased confidence and a deeper understanding of the CASSP materials.
- Teachers reported that they benefited from being involved in the project as their teaching practice had improved and the project encouraged them to reflect on their

teaching and students' learning with their peers and focus more on their teaching pedagogy. Thus, the teachers' initial concern about needing new effective pedagogy was addressed by this innovation.

Theme Three: Factors Influencing the Change Process

A number of factors have been identified by this study as impacting on the success of the teachers' professional learning. These factors are represented in the third conceptual framework component (Figure 8.11) as impacting factors that were important in the overall success of the project.

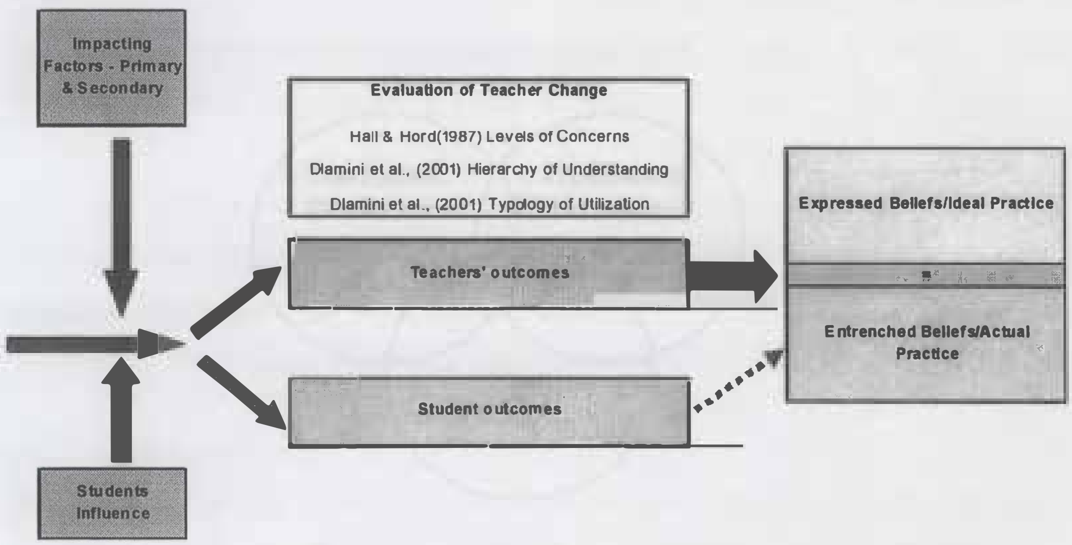

Figure 8.11: Conceptual framework component 3

The impacting factors are divided into two groups, primary and secondary. The primary impacting factors include the components of the CASSP model. The secondary impacting factors include those factors that impacted on teachers' practice but were not components of the CASSP model.

Primary impacting factors: Aspects of the CASSP Model, including

- participative inquiry which provides time for reflection
- professional development workshops which provide explanations and modelling of new strategies, and
- curriculum resources to exemplify the strategies

- Secondary impacting factors
  - change process takes time
  - leadership

- support structures outside the school
- commitment and support at the school level, and
- a shared vision for teachers

Primary Impacting Factors: Aspects of the CASSP Model

The CASSP model incorporates three components, professional development, curriculum resources and participative inquiry. Research has demonstrated that these components have been successful in promoting change individually and it is expected that integrating these components would have a synergistic effect (Goodrum et al., 2003)

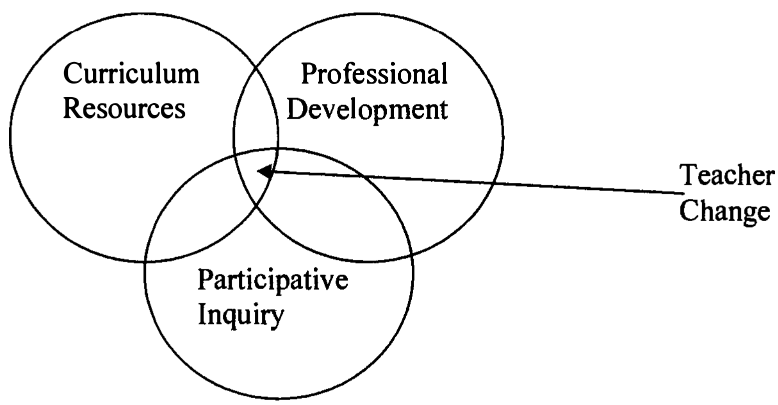

Figure 8.12: The CASSP model showing the relationship between the components (Hackling et al., 1999a).

The participative inquiry component, provided times and space for teachers to reflect on their practice. The professional development component provided explanation and modelling of new practice. The curriculum resources provided an exemplar to demonstrate how student-centred and inquiry-orientated strategies could be integrated with effective assessment strategies to form a coherent sequence of learning experiences.

The following assertions summarise teachers' opinions about the value of the three CASSP components (Figure 8.13).

Assertions

Seventy-two percent of the participative inquiry was conducted informally, with teachers citing the major benefits as peer collaboration (28%) and reinforcement of the CASSP strategies (20%) (Assertion 4.7, Chapter 4, Tables 4.34 and 4.35).

Teachers benefited from time and reflection set aside in the PI to consider their teaching practice (Assertion 5.5, Chapter 5)

Ninety-five percent of teachers rated the professional development as effective or very effective with collaboration and learning new strategies as the two major benefits (Assertion 4.7, Chapter 4, Tables 4.26, 4.27).

Fifty-nine percent of teachers rated the student resources as effective or very effective, with teachers' concerns relating to the presentation of the material (Assertion 4.7, Chapter 4, Tables 4.22, 4.23).

Figure 8.13: Assertions pertaining to the CASSP model components.

Time for reflection

In the CASSP project, teachers reported finding time set aside for reflection after teaching with the curriculum resources to be valuable (Assertion 5.5, Chapter 5). The participative inquiry (PI) sessions were designed to be facilitated by the school's project coordinator, and scaffolded by questions from the teacher's resource book. The PI sessions were designed to encourage teachers to share their classroom experiences with their peers and the questions sought to focus the discussion on professional rather than administrative issues.

Ann, in School A, reported at interview that she had found the participative inquiry to be very enlightening. Through the PI sessions, she realised that the participating teachers at her school had quite different beliefs about teaching and learning. She thought these differences might explain why consensus about everyday issues such as assessment items was so difficult (Ann, Interview Three, 27/3/02). Teachers at School B lamented the lack of formalised PI sessions over the course of the innovation, but they did participate in many informal PI sessions in their staffroom (Assertion 5, Chapter 5). The Researcher was present at some of these informal PI sessions and noted most were about the practical details of the activities in the module, with teachers expressing mainly task concerns. Beth reported that after one science staff meeting, teachers were asked to contribute their thoughts about the project. Beth remembered

> it was done in a forum with all of the science staff so you don't necessarily feel comfortable.....you don't feel that they really need to hear all that sort of stuff if they're not teaching it so that wasn't ....as far as, we haven't used that (PI) as effectively or how it was supposed to be used.
>
> (Beth, Interview Two, 30/8/02)

The environment created at the formalised participative inquiry sessions at School B was not conducive to encouraging staff to be open and reflective about their practice.

At the conclusion of the topic the case study teachers were asked about the value of continuing the participative inquiry discussions. They indicated that the participative inquiry during the trial had been valuable, however, they had concerns about attending future sessions due to a lack of available time. In school A, Amy and Ann cited extra-curricula activities before and after school and over lunch times, which made it difficult for all science teachers to meet. Amy went on to say that when she first started teaching many years previously, subject year meetings were held frequently in a formal way, however, with the increase in workload and extra-curricula activities they were impractical in the present school climate. She thought that holding meetings in the future would be useful, if time could be set aside, and that the questions had been important in providing a focus to the discussions (Ann and Amy, Interview Two, 27/8/02).

The idea of cycles of action and reflection, further action and reflection that form the basis of participative inquiry is very important in promoting the process of change. Reason and Bradbury (1994) contend that action without reflection and understanding is meaningless. They also contend that this form of inquiry into practice is more meaningful to teachers, as it hands control back to them, as the major stakeholders in the project. In considering their evaluation of all the stakeholders in the process, it is conceivable that Reason and Bradbury (1994) would consider involving the students in the process of action and reflection as they are also stakeholders in the teaching and learning process. Reason and Bradbury (1994) envisage an ever changing and evolving process that changes as teachers develop their skills and understanding. Trial teachers reported that they had received many benefits from taking part in the participative inquiry, however, were unsure if they had the time to continue with formal PI in the future.

Explanation and modelling

A professional development program was developed for the CASSP project. The CASSP professional development was designed to incorporate explanation the modelling of strategies within a constructivist framework: individual teacher reflection, peer teacher collaboration with teachers from their own science department and from other schools; and, opportunities to address teachers' concerns through problem-solving sessions.

The CASSP professional development sessions were designed in three stages so as not to overload the teachers with information in one session, and assessment materials were deferred until the second professional development mid term. Session one of the professional development was held before the holidays, where many of the CASSP strategies were modelled with teacher activities. The structure of the CASSP professional development was carefully considered to emulate the student-centred constructivist strategies presented to students in the classroom. The professional development modelled the strategies that it was hoped the teachers would implement into their classroom practice. Teachers were encouraged to participate and be active and independent learners, and in this way experience the strategies from their students' perspective. Professional development sessions were designed with experiences in the form of activities presented before explanations were given, and teachers were encouraged to collaborate with their peers in small groups, and use their prior knowledge as a basis on which to construct their new knowledge.

Many of the teachers had seen the benefits in the design of the professional development (PD) component of the project. In the first interview Ann reported "I think about the actual activities that we did and how they demonstrated some of the things we need to do in the classroom, so that was good" (Ann, Interview One, 22/7/02). Amy was also impressed by the PD and felt that the both sessions were extremely good at demonstrating the CASSP strategies and Beth confirmed "The assessment was excellent" and she went on to report "....talking about different types of assessment and the ways we can use them differently was really useful" (Amy, Interview Two, 30/8/02) (Beth, Interview Two, 30/8/02) (Assertion 4.7, Chapter 4, Tables 4.26, 4.27).

The second and third professional development session provided opportunities to address teachers' concerns and any problems they were experiencing. Researchers used an anonymous approach to elicit from teachers the problems they were experiencing and then organised the teachers into small groups so they could work collaboratively to develop solutions to the problems. Teachers reported enjoying the opportunity to discuss the innovation and any concerns with other teachers, Beth reported it was "good to hear from different groups and different schools and how they're having issues and things" (Beth, Interview Two, 30/6/02)

The Western Australian teachers reported they had enjoyed the professional development sessions, and cited improvements in peer collaboration and gaining greater knowledge of the CASSP strategies as the greatest benefits from their experiences. The teachers were supportive of the number of professional development sessions in the CASSP trial, with some commenting that any further time away from their classrooms would disrupt their teaching programs.

Teachers should also be considered as learners, constructing professional knowledge in the same fashion as their students. As Watts et al., (1997) explains teachers' classroom practice is linked to their understanding of how students learn and their own experiences (Watts et al., 1997). In order to teach more effectively, teachers must understand the pedagogies that best enable students to learn for understanding. To construct this new professional knowledge requires teachers to assemble and integrate new learning into their existing experiences (Hewson & Hewson, 1984; Laugksch, 2000; Loucks-Horsley et al., 1998). The CASSP professional development was designed to help teachers construct an understanding of effective teaching and learning strategies in their classroom. By modelling strategies of best practice researchers were ensuring teachers were learning using the most effective strategies available, as well as seeing the impact of those strategies on a group of learners.

Curriculum resources to exemplify the strategies

Curriculum designers Goodrum et al. (2003) described the curriculum resources, in particular the student resources in the CASSP project as

> a powerful driver of change. It enabled teachers to implement and experience changed practices that were the focus of the professional development program (p.1).

It was acknowledged that producing quality resources takes considerable time, effort and expertise; consequently the materials were developed by a team comprising two science education experts, a state education department science curriculum officer and an experienced science teacher. Some teachers expressed the view that the curriculum materials lacked the polish of a professionally published book. Another aspect of the material that concerned teachers was how closely the materials' objectives fitted with those of the school module objectives. The discrepancy, in some schools, between the materials and their course objectives were due to the wider CASSP application. The project was trialled nation wide and the materials were designed as a best fit for all participating States and Territories. Teachers added supplementary material where necessary, and later in the term, reported adapting the materials to suit their lesson times and to the ability level of their students which varied from school to school. Overall, 59% of the WA trial teachers supported the student book rating it as effective or very effective. Many teachers reported not using the teacher resources in their day to day lesson planning. Goodrum, Hackling and Trotter (2003) also reported that the Australian CASSP teachers used the student resources to a much greater extent than the teacher resources. It is conjectured that the limited use of the teacher resources may be due to time pressures experienced by teachers during the trail. The student resources contained the practical component of the strategies ready to be implemented into the classroom, the teacher resources contained more of the underpinning theory behind the CASSP strategies. It is speculated that if further trials were carried out and if the resources used again teachers would have time for reflection and consequently utilise the teacher resources to a greater extent (Assertion 4.10, Chapter 4, Tables 4.22, 4.23).

Case study teachers at School A reported having good quality resources available to help them; the teachers felt that their existing materials were written to encourage student-centred learning (Participative Inquiry, Session Two, 30/8/02). Consequently once the case study teachers at School A had finished using the CASSP materials, they were able to use their textbook to plan further inquiry learning opportunities. Teachers at School B reported that previous to the study they did not have enough text material for all the students in the class, classes shared resources, and that their previous text was not written from a student-centred perspective. The teachers and students at School B were pleased with the CASSP curriculum materials, as each student participating in the trial had their own book for the duration of the project.

Teachers' input is an essential component in the development of the curriculum resources, as they are responsible for its successful implementation into the classroom. Teachers' were encouraged to trial and evaluate all aspects of the resources providing feedback to the researchers on changes that would improve the resources. The materials have been amended based on all the feedback from the trial.

The curriculum resources are described as the major driver of change during the CASSP project, they have provided teachers with constant extensive support throughout the CASSP trial. In a similar way to the modelling of the professional development, the curriculum resources have provided teachers with examples and models of learning sequences to use in their classroom (Loucks-Horsley et al., 1998). The student resources were designed with the CASSP strategies embedded into their structure, enabling teachers to use these materials to facilitate students learning. The cost of producing quality resources to facilitate change as commented on by Bybee (1997) is high, but the benefits he perceives are extensive. Without these resources it is unlikely that the other components of the CASSP model would have been able to sustain changes to teachers practice over the course of the trial. Teachers, particularly those without suitable student-centred inquiry based materials, were very dependent on the resources. Three of the case-study teachers were unable to be independent of the CASSP resources, thus indicating their importance in sustaining changed teaching practices.

Secondary Impacting Factors

Several factors, other than the CASSP components, that impact on the teachers' ability to change were identified.

Change process takes time

It is generally acknowledged that the implementation of innovations requires time (Bybee, 1997; Loucks-Horsley et al., 1998). Kotter (1995) acknowledged

> The most general lesson to be learned from the more successful cases (innovations) is that the change process goes through a series of phases that, in total, usually require a considerable length of time (p. 59).

Although Kotter was referring to companies in the business sector rather than to schools in the education sector, the premise stands that it takes time to embed new strategies into practice. This thesis contends that in order to reach sustained and permanent change, there must be changes to teachers' underlying beliefs.

Research has determined that changes to practice sometimes requires months or even years before the changes are fully implemented as teachers need time to practice, reflect on their practice, learn new skills, develop new understandings and revise existing beliefs about best practice. Bybee (1997) suggests that changes of the nature proposed by the CASSP project that involves large numbers of staff can take many years to implement into schools and needs the support of sustained professional development until the changes are embedded into teachers' practice.

Unfortunately there is not an unlimited amount of time available in which to bring about change to teachers' practice, as this would result in unacceptable financial cost. Most teacher change initiatives are single 'hit and run' events, which advocate change after a single professional development session or after presenting teachers with a new resource, which as Fullan (1995) reports "fails to have a sustained cumulative impact" (p. 253). Loucks-Horley et al. (1998) and Bybee (1997) espouse longer more sustained intervention, but are both quick to acknowledge the increased costs and benefits associated with larger more sustained interventions. As Bybee (1997) points out in his table about the cost of educational reform (p. 38), the ambition of a project such as CASSP, designed to initiate changes to teachers' practice and their underlying beliefs, has both high costs and benefits. He contends that although there is a high risk to teachers, great expense to the school and extensive constraints against reform within schools there are extensive benefits to the teachers and students.

Financial constraints limited CASSP to a single term of 10 weeks, with three professional development sessions and an experienced change facilitator who coordinated the CASSP project in all the States and Territories.

As it takes time to change teachers' beliefs and practice, the evaluation of any change innovation must acknowledge that time will always be a factor impacting on its success (Bybee, 1997; Loucks-Horsley et al., 1998).

Leadership

In developing the CASSP model, the researchers were aware of the importance of leadership in promoting and sustaining change, consequently when inviting schools to participate in the CASSP trial one stipulation of involvement was the nomination and inclusion of the Head of Department to act as Project Coordinator in the Project (Goodrum et al., 2003). From the assertion in Figure 8.14 below, it can be seen that the project leader in each school needs to play an important role in helping to facilitate the participative inquiry discussions, model strategies and support teachers through the change process.

Assertion **Leadership is considered a critical factor in promoting teacher professional learning and change to practice. Without strong and positive modelling and appropriate support from the Head of Department and/or Project coordinator, the change process can be severely limited (Assertion 5.7, Chapter 5; Assertion 6.1, Chapter 6).**

Figure 8.14: The role of leadership in effecting teacher change.

Researchers have identified a large number of traits that characterise effective leadership, these include; being supportive and responsive, and concerned with the feelings of others; fostering participation and listening to others; setting goals; approaching problems with facts and attending to details; being a skilful negotiator of conflict; being persuasive; being able to communicate a shared vision; and inspiring others to be enthusiastic (Bolman & Deal, 1992).

Many of these characteristics have been identified as vital in fostering support and collaboration among teachers in the CASSP project. Consequently the CASSP researchers identified the need to establish a project leader/coordinator at each school to provide teachers with ongoing support and coordination during the project. In most schools it was the Head of the Science Department who was assigned to the role of Project Coordinator. In this way the project organisers were sure that the project was a mission that the entire science department was prepared to commit to, even if it only directly impacted on a few teachers therein. These leading teachers were to act as 'change facilitators' (Hall & Hord, 1987) by making interventions and consequently helping teachers make changes to their practice. These interventions could have been as minor as asking the teacher how the innovation was proceeding on the way to morning tea, or as major as organising to team teach with a teacher who was displaying difficulties with aspects of their classroom teaching.

The importance of leadership and the role of the project coordinator were clearly demonstrated when examining the two case study schools participating in the study. In School A, the Project Coordinator was an enthusiastic participant in all aspects of the innovation. He was very familiar with and supportive of the project aims and was influential in helping to promote the project. The Project Coordinator in School A persuaded the administration of the school to support the project by providing relief teachers who would supervise participating teachers' classes so they were able to hold participative inquiry sessions within teaching time enabling all teachers to attend. At each participative inquiry session, which was scheduled with plenty of advance notice, the Project Coordinator provided all staff with written questions from the CASSP participative inquiry resources to focus and direct the meeting. He was an extremely able facilitator, ensuring teachers remained focused on task and within the designated timeframe. The Project Coordinator was also very aware of the teachers' concerns about the pressure exerted by assessment on classroom practice. Consequently he volunteered to write the end of topic test using items from the CASSP assessment web site including only those areas all the teachers had covered by the end of the topic.

At the end of the term all the participating teachers were invited to lunch with the Principal and Deputy Principal of Curriculum Studies and in a relaxed setting over lunch, each teacher was asked to outline their feelings about the project and whether they felt it was successful.

In School B the Head of Department was also the Project Coordinator and like the Project Coordinator at School A did not teach any Year 9 classes himself. The Project Coordinator at School B was only able to provide teachers with limited support. Some formal participative inquiry sessions that were going to be held were cancelled or postponed. At the one session the Researcher did attend he appeared to be unaware of the participative inquiry questions and consequently did not direct or focus the meetings. Beth reported that the participative inquiry sessions made her feel uncomfortable and unwilling to share her thoughts and ideas about the progress. The Project Coordinator was not seen to attend any lessons by the participating teachers. The Researcher did not observe any instances of the Coordinator providing advice to the participating teachers, although he was a very experienced teacher who had taught science for 30 years (Assertion 6.1, Chapter 6).

Loucks-Horsley et al. (1998) recognise in their change principles the importance of the proactive support of leaders in initiating and sustaining change. School leaders, particularly the heads of department, are in a position to be effective change agents who can make the necessary interventions to keep the change process on track (Hall & Hord, 1987). Hall and Hord (1987) state that effective leaders intervene directly and constantly to ensure that teachers do not lose sight of their goals, and it is often the leader who is able to remain focused on the final objectives and not get caught-up with the everyday minutiae of the classroom. *The Science in Schools Research Project* (Deakin University Consultancy and Development Unit Faculty of Science et al., 2003) acknowledged the importance of leadership in precipitating change. The project identified factors that leaders' possessed that made them more effective enablers of change. These included having a "familiarity and commitment to the principles underlying" the project which allowed leaders to "support and challenge teachers to develop new practices" (p. 70). They determined that effective leaders were skilled change agents who were able to intervene to direct and encourage teachers, were familiar with teachers' beliefs, practices, prior knowledge and their changing needs throughout the project. Finally their leaders worked closely with the school's leadership team enabling them to seek funding and resources as needed by the project and report on the progress of the project (Deakin University Consultancy and Development Unit Faculty of Science et al., 2003).

In their report on the national CASSP trial, Goodrum, Hackling and Trotter (2003) reported that leadership demonstrated by the heads of science department and the project coordinators impacted on the effectiveness of the change process at the schools. In schools where leaders were identified as effective (e.g. in School A), the change process was more successfully sustained than in schools where the leader did not demonstrate any of the identified characteristics (e.g. in School B).

Support structures outside the school

The CASSP project had a number of outside support structures in place to promote change; these included the CASSP project director, State and Territory Education Officers, and the CASSP web site.

The CASSP project director was available to the teachers during the professional development sessions and by phone or on-line during the project. He was an experienced science educator who was able to respond to questions and concerns that teachers had during the professional development sessions. He used the professional development sessions to encourage teachers to collaborate with teachers from their own school and from other schools, discussing their experiences and sharing problems. He was an expert at facilitating large and small group discussions and helping teachers share experiences in a supportive environment. From the participating teachers' perspective, this person was a supportive and valuable asset, who was genuinely and enthusiastically interested in all the experiences of the CASSP teachers.

The State and Territory Education Officers formed a reference group to guide the project and were important stakeholders in the CASSP trial. The representatives of the state and territory education departments found common goals and shared a vision for lower secondary science education in Australia. As Goodrum, Hackling and Trotter (2003) reported, part of the success of the CASSP trial was the collaboration of these important educators and the formulation of a project that was accepted nation wide. From the participating teachers' perspective, the support of these very influential educators demonstrated their commitment to the project at the highest level. In Western Australia, the state education officer attended the three professional development sessions, he was interested in the teachers' experiences and keen to address any issues raised by the teachers.

The other support structure that assisted the participating teachers was the CASSP web site. It was set up with a message board where teachers could exchange ideas about the project, post questions to the project director, and collaborate to solve problem with other teachers throughout the country. The web site also contained a section on assessment with a large number of assessment items and complete answers. The web site was available to all the teachers involved in the project providing them with formative and summative assessment items. Unfortunately the web site was not posted at the beginning of the innovation, and the assessment component was not uploaded until much later in the study. School A had excellent technical facilities; each staff member had their own lap top computer and internet connection at their desks in the science staffroom. Amy was very organised and her first test was composed of assessment items form the website item bank.

School B had severely limited technical resources and the school server was down from almost the entire duration of the innovation, consequently many teachers from the school were unable to access the web site until late in the term. Beth was able to access the site during the term, and downloaded the assessment items and solutions, however, the others including Bob, professed to be too busy to allocate time to examining the web site (Chapter 4, Table 4.34).

This study found that outside school support does help sustain teachers through the change process. The CASSP project director and the State and Territory Education Officers were important people to the CASSP project, and the CASSP web site provided additional material and an opportunity for further collaboration among the teachers throughout the country. The CASSP project director provided support and encouragement directly to the teachers at the professional development sessions. As an expert change agent he was able to provide suitable interventions during the professional development. He addressed teachers concerns or set up situations where teachers could interact and support each other (Hall & Hord, 1987). The State Education Officers involvement provided the teachers with the knowledge that this project was valued at the highest level, and it was intended to be adopted by all science teachers throughout the country on its completion. The CASSP web site was important in providing teachers with assessment structures to encourage them to assess higher order cognitive skills and understandings in a real-world context. The web site also provided teachers with a facility to maintain contact with other teachers and education experts to address any concerns they had when they required it. It was unfortunate then that the web site suffered technical problems as was not available until near the end of the trial, and that through technical constraints some schools had problems accessing the web site.

Commitment and support at a school level

Research indicates that support from the school administration is very important in ensuring the success of a change innovation, and the more substantial the innovation the more support is needed (Bybee, 1997); (Figure 8.15).

Assertions
The school administration at School A was influential in supporting teachers' professional learning. (Assertion 5.3, Chapter 5).
The teachers lacked overt support from the school administration at School B and this may have limited the impact of the change innovation on teachers' professional learning (Assertion 6.2, Chapter 6).

Figure 8.15: Assertions relating to the impact of the school administration

The school administration including the Head of the Science Department, the Principal and Deputy Principal were important in providing support for the teachers and providing them with the necessary time and resources, if needed, to enable them to participate in the trial. The Researcher felt that there should have been a review of the curriculum objectives for the Energy unit and the end of unit test at each school to reduce the pressure on teachers to 'get through' the usual content before the test. A restructure of the end of topic test would have also ensured that the teachers assessed the students' understanding of the material and not their ability to recall the facts they had rote learnt.

As reported the administration at School A was very supportive of the CASSP trial. In School A, the objectives of the Energy unit were reduced to remove the pressure on the teachers to teach all the usual objectives. The teachers also participated in a luncheon with the School Executive to discuss the trial and their views on its outcome. This luncheon not only updated the administration on the project but also ensured the teachers felt valued and their opinions important. In School B the Head of the Science Department was only able to provide limited support and there was no overt acknowledgement by the School Administration of the CASSP trial. These teachers felt isolated, as their efforts to change their practice were not recognised by the School.

As Bybee (1997) and Hall and Hord (1987) argued, teachers need to be supported in their efforts to change their practice, and the school executive including the school's principal is important in promoting and sustaining change. They contended that principals, school executive and teachers needed to share a vision for change within their school. Hall and Hord (1987) advocated that principals should be exceptional change agents who with skill and the appropriate interventions could guide and focus the change process for teachers within their school. This study has shown that modern day principals often have limited contact with the classroom teachers in their schools. In Schools A and B the Principals had a very different approach and consequently provided very different levels of support during the change process. At School A the Principal sought contact with the teachers participating in the CASSP trial and was supportive in asking them to discuss their experiences and views about the proposed changes to their practice. The Principal at School B was not seen to be supportive of the change process, in fact the Researcher did wonder if the Principal was aware that some of the science teachers were participating in the project.

A shared vision for peer teachers

Teachers' peers are those people, usually other teachers in the same department, whose opinions and beliefs impact on the teachers' beliefs and their practice. The assertion in Figure 8.16 outlines the importance of peer influence on change.

Assertion
Peer influence acts as a powerful force in facilitating or limiting teacher change (Assertion 5.6, Chapter 5 ; Assertion 6.3, Chapter 6).

Figure 8.16: Assertion relating to the impact of peer influence on teacher change

Teaching has often been described as an isolating and lonely profession, where teachers teach their students with relative autonomy. This study found that most teachers enjoyed the opportunity to leave their classroom to consult, discuss, problem-solve and compare aspects of teaching and learning with other teachers. Teachers commented frequently on how much they enjoyed communicating and interacting with other teachers outside their normal routine. Teachers cited the best benefit of the participative inquiry was allowing teachers to participate in peer support and collaboration (Assertion 4.7, Chapter 4, Tables 4.34 and 4.35). This ranked higher than teachers reflecting on their practice and carrying out action research in their own classrooms. Teachers also reported the importance of peer interactions in the professional development sessions. Case study teachers, Amy and Bob cited the ability to discuss and problem-solve with teachers outside of their school as very valuable and a very important component of the professional development (Amy, Interview Two, 27/8/02; Bob, Interview Two, 27/8/02).

Teachers at School B did not have an opportunity to discuss their experiences with their peers, except with other teachers in the same staffroom during informal discussions. Teachers within each staffroom often talked about CASSP, although this was more centred on the mechanics of the activities not the underlying pedagogical framework. Beth and another young female trial teacher (B1) at the school experienced very positive responses from their students during the trial. Beth's students were keen to participate and work through lunchtime to complete their electrical projects. B1 arrived in the science staffroom several times elated over how enthusiastic the students were in completing a number of activities. In one instance students had prepared a project related to the electricity component of the unit; B1 was so pleased with the hard work and innovative designs the students produced, she asked the Researcher to attend the class to see the students' projects. Beth and B1 were very excited with their students' responses to the trial and enthusiastically sought to share their experiences with Bob and other teachers in the department.

In School A there was one participating teacher (A2) who did not share the same vision as the other teachers participating in the innovation and was very negative about all aspects of the innovation. Consequently she caused concern and angst amongst the other teachers and this had a significant impact on their teaching practice. Her negativity and her attempts to redirect the project by influencing the topic test generated considerable discussion in the staffroom and created tension between other teachers participating in the trial. The other teachers did not want to confront A2 but did not want to use her test that addressed many objectives that they had not included in their unit that term. A2 wanted to reintroduce a number of objectives back into the Energy unit, citing their importance in preparing students for further upper school study. A2 used every opportunity to complain about the CASSP trial including most formal and informal participative inquiry sessions, she returned to her old text materials as soon as possible after the trial.

Teachers in this trial were very vocal about their support for peer collaboration and considered it a very important benefit of the project. As seen in the anecdotes the case-study teachers were strongly influenced by a number of their peer teachers. In School A, the peer teacher's beliefs were at odds with the other teachers in the trial, this caused the teachers consternation and anxiety. The positive sway of Beth and B1 was influential to other members of the trial at School B who shared their science staffroom. This influence, however, was limited by the geographical isolation of the science teachers in different offices and the lack of formalised meeting experiences of the participating trial teachers at School B.

Summary

A number of factors have been identified that had an impact on the success of the CASSP project and these have been divided into two groups, primary and secondary factors.

The primary factors are those core components of the CASSP model. These are;

- Teachers need time and a suitable setting in which to reflect on their classroom practice and determine how they can make changes to become more effective teachers. The Participative Inquiry component of the CASSP model provided resources to support teachers collegial discussion and reflection which was based on a modified form of action research (Reason, 1994)
- Explanation and modelling of new strategies was determined to be an important factor in precipitating change, and was provided through the Professional Development component of CASSP.

- The curriculum resources were important drivers of the change process providing concrete exemplifications of the CASSP strategies. The majority of the Western Australian teachers and those in the Australian study (Goodrum et al., 2003) indicated that the student resources were very useful. Some of the case study teachers were not able to sustain the new strategies without the support of the student curriculum resources.

The secondary factors were less important than the CASSP components but still impacting on the overall success of the project. These factors included; internal school elements, leadership, school hierarchy and peer support and other elements including time and those significant figures outside the school.

- It has been acknowledged that changing teachers' beliefs and practice takes time (Bybee, 1997; Hall & Hord, 1987; Loucks-Horsley et al., 1998). Bybee (1997) argues that the larger the innovation, the greater the risk and the more time and resources required. The CASSP innovation included a large number of teachers and attempted to make significant changes to their beliefs and practices. For many teachers, one term was not long enough.
- Leadership has been identified as a significant factor that impacts on the success of a change innovation (Hall & Hord, 1987; Loucks-Horsley et al., 1998). In this study, the role of the School Project Coordinator was important in supporting teachers and encouraging them to consider their practice and the effectiveness of the proposed strategies. The Project Coordinator facilitated the participative inquiry and was also available to support and guide teachers during the trial. The quality of the coordinators leadership in School A and B contributed to the success of the project in School A and limited the success in School B.
- Three major support structures outside the school were identified as influential in precipitating change in the CASSP trial. These support structures were the project director, the State and Territory Education Officers, and the CASSP web site. The director facilitated the professional development sessions and addressed the concerns of the participating teachers. The State and Territory Education Officers endorsed the project in and indicated it was supported by their states' education department. The web site provided peer support for teachers involved in the project and additional materials for assessment.

- All change innovations implemented in schools require the commitment and support of the principal and other executive members of staff (Hall & Hord, 1987). The CASSP trial was seen to be effectively supported in School A, but not overtly acknowledged or supported in School B by the school administration.
- This research has also demonstrated the importance of teachers' peers in the change process. Teachers who are enthusiastic and successful participants of the change innovation will lead and support their peers to strive to make changes to their practice.

Theme Four: Students' Views of CASSP

As Doyle (1979) explained "the actions of teachers are judged by the learning outcomes of the students" (p.139) so consequently students' expectations, perceived learning experiences and enjoyment of science are important indicators of the success of the innovation. The study aimed to increase student engagement and enjoyment of science.

Samples of students from classes of each case-study teacher were interviewed in discussion groups and all students completed a questionnaire.

This theme addresses three aspects of the impact of the innovation on students, **teachers' perception of the impact of the project on their students; students' views about the impact of CASSP on their learning;** and **the school context** and how it influences the students' aims and expectations and consequently their interest in and enjoyment of lower school science.

Teachers' Perception of the Impact of the Project on their Students

Based on their classroom observation and from student feedback, the majority of the Western Australian teachers felt that the students had enjoyed participating in the project and as a result had become more independent learners (Figure 8.17). Teachers recognised that students were more motivated and engaged in science during the CASSP trial. With 62% reporting their students enjoyed the unit, this compares favourably with the national percentages (24%) of students excited by science lessons in (Goodrum et al., 2003).

Assertion

Sixty-two percent of teachers reported their students enjoyed part or the entire unit. The significant majority of teachers (78%) felt that their students had gained from the CASSP project with the major benefits including; students becoming more independent learners (24%), developing investigative and group skills (12%) and increased understanding of concepts (12%) (Assertion 4.10, Chapter 4, Table 4.38, 4.39).

Figure 8.17: Assertion relating to the Western Australian cohort teachers report on the impact of the CASSP trial on their students.

In their final questionnaire a small number of teachers noticed differences between their classroom observations of their students, and students' feedback on the survey. These teachers reported that their students were interested, on task and participating in the classroom activities, however, in the student survey, these students reported that the science during the trial was uninteresting and irrelevant to their lives. Teachers had no way of explaining this discrepancy, although some teachers' suggested that students do not want to be seen enjoying science. Others teachers speculated that whilst the students enjoyed participating in the investigations they did not enjoy the physical science topic.

There is marked difference that exists between the content of science versus science process. Recent discussion of the importance of scientific literacy has promoted the importance of the process of science and being able to apply and use science, rather than the memorisation of science facts (Bybee, 1997). Teachers and science education researchers are seeking to encourage students to become more scientifically literate, to apply their science knowledge and use it to make sense of their world. It is feasible then, that students were concerned about the relevance of the content they had learnt in the classroom, but found the process skills enjoyable and interesting.

Students' Views about the Impact of CASSP on their Learning

Students were canvassed to determine the impact of the project on:

- motivation and enthusiasm for science;
- acknowledgment and identification of the CASSP strategies; and
- the relevance of science to their lives.

Assertions

Sixty percent of students at School A identified their science experiences during the CASSP trial as different from normal. Many of the strategies embedded in the trial were identified although not necessarily supported by students (Assertion 7.1, Chapter 7, Tables 7.2, 7.3, 7.4).

Eighty-six percent of School B students identified their science experiences during the CASSP trial as different from normal. Many of the strategies embedded in the trial were identified and mainly supported by students (Assertion 7.3, Chapter 7, Tables 7.14, 7.15).

At School A, only 36 % of students reported that the CASSP project had made science better that term, at School B 74% of students reported the science was better whilst participating in the CASSP project (Assertion 7.5, Chapter 7, Tables 7.5, 7.15).

Some students surveyed were unable to see the relevance of science to their lives (Assertion 7.6, Chapter 7, Tables 7.6, 7.15).

Figure 8.18: Assertions relating to the impact of the CASSP trial on case-study teachers' students

Motivation and enthusiasm for science

From the questionnaire, Western Australian teachers identified effective students as those who were motivated, interested and engaged, and came to class ready to participate and take control of their own learning.

Biggs and Telfer (1987) have identified two forms of motivation; intrinsic motivation (reliant on the students' natural curiosity); and extrinsic motivation (reliant on the input of external factors that drive students' desire to succeed). Forms of extrinsic motivation include instrumental, social and achievement motivation. Instrumental motivation relies on positive (ie. praise) and negative reinforcers (ie. punishment) to drive students' progress, while social motivation relies on students wanting to please other individuals (ie. teacher, friend or parent), and students motivated by achievement seek to compete with their peers, this is seen to be important when school organisation is set up to make students' results are made public (Biggs & Telfer, 1987).

Biggs and Telfer (1987) identify intrinsic motivation, as leading to 'high-quality' involvement of the learner that is self-maintaining. This type of motivation is considered to lead to deeper learning and greater understanding. How then do teachers help students to be intrinsically motivated by science? Biggs and Telfer (1987) suggest creating a conceptual conflict between what students already know and what they are currently learning which will motivate students to address the issues to resolve the conflict. The diagnostic assessment items embedded in the CASSP student resource book had the potential to create conceptual conflict.

Students in Ann's class (School A) obtained for the most part good grades, however, in the survey and in the group interview reported low levels of interest and enjoyment (Ann's Class Group Discussion). While Amy's class seemed interested and engaged during some lessons, there were other lessons where this class was neither engaged nor interested in science. In the discussions with members of this class, these students admitted that they generally did not like science and considered they were 'not good at it' (Amy's Class Group Discussion).

In Beth's class at School B, the boys were obviously very engaged and interested in their science activities when they sought permission to work through lunchtime to complete electronics tasks (Lesson Observations 1/9/02, 2/9/02, 3/9/02 and 10/9/02). The female students in Beth's class, however, reported that the science they had completed that term during the trial had been boring and uninteresting. This is not an unusual gender difference experienced in a physical science topic like Energy, boys reporting they really enjoyed the topic whilst the girls reported the topic was not interesting to them (Beth's Class Group Discussion).

In conclusion, the students at School A were not intrinsically motivated by the physical science topic. Theirs was extrinsic motivation either achievement motivation to compete with their peers for the best grades, social motivation to please parents, teachers, and often instrumental, related to reinforcers such as getting an A grade, or not being grouped into the bottom science class. Many of the students at School B were more intrinsically motivated by science that they were interested in (ie. how house fuses work), although this did not extend to all the students (Bob's Class Group Discussion).

Acknowledgment and identification of the CASSP strategies

Most of the students interviewed were able to identify the CASSP strategies and acknowledge that the science had been different during the CASSP trial. In the student group discussion the students at both School A and B had been able to identify many of the strategies embedded in the CASSP trial, but how students perceived these differences at School A was vastly different from School B.

The majority of the students at School A did not perceive these changes as beneficial to their studies in science and were opposed to the changes. As previously described part of the problem stemmed from the assessments with which the students were familiar. These students were used to driving the learning at a fairly rapid rate and had specific expectations about the nature of the assessment which guided how much and what material their needed to attend to. Students in Ann's class were very concerned about the changes in the assessment structure of the course and were constantly asking questions about aspects of assessment. Doyle (1979) noted that students are very selective about the material they attend to in the classroom, as they seek to attend to information that will give them the highest performance grade. He determined that the more information students can gain about the task structure of the assessment the more specific their attention to the information can be. Observations in this research lead the Researcher to conjecture that students in Ann's class were very skilled at determining the exact nature of the assessment demands and consequently only attended to the necessary material to get the highest grades. When participating in the CASSP trial the students were unsure of the assessment demands and were anxious and concerned as they were not able to narrow their selection of materials to which they would attend (Doyle, 1979) (Ann's Class Group Discussion) (Amy's Class Group Discussion).

The strategies encapsulated in the CASSP trial promoted deeper learning, and used students' prior knowledge to stimulate their intrinsic motivation. Entwistle (1981) identified three study strategies with a cluster of factors that described students learning. The strategy which the CASSP trial sought to promote encapsulated deep, comprehensive learning and intrinsic motivation (Entwistle, 1981). Entwistle (1981) also identified the study strategy that encompassed surface, operational learning, and extrinsic motivation where these students are bound by the syllabus and anxious about failing their subject. The final strategy incorporates a strategic approach, where students are organised and motivated to achieve results, but show little involvement in their tasks (Entwistle, 1981). Observation in this research indicated that deep learning was not the learning these students ordinarily experienced. Students at School A were identified as using surface or strategic approach to their learning.

The students in School B perceived the changes more positively and reported that they had completed more activities during the term, taken less notes and were able to work at their own rate on some occasions (Beth's Class Group Discussion) (Bob's Class Group Discussion). Observation in this research indicates that some of the students experienced deeper and more comprehensive learning being intrinsically motivated to satisfy their curiosity. Not all students at School B learned more deeply, some students especially in Bob's class were not motivated or on task.

The relevance of science to their lives

Students in both schools struggled in many cases to see the relevance of the science they were learning. A small number of students (6 - 11%) reported throughout the survey that Physics/Science was irrelevant to them (Chapter 7, Table 7.2, 7.6). The girls in School A, particularly, were often scornful of some of the ideas from the Energy unit. Unless these students in School A could see a direct and immediate use for the science, it was deemed irrelevant and unnecessary (Ann's Class Group Discussion) (Amy's Class Group Discussion). The students surveyed in School B were less concerned about a direct and practical use for the information in their future careers. These students were more able to see that the science in the CASSP trial was relevant and practical. One student cited it was relevant to understand and be familiar with fuses in the electricity component of the topic and he could see the application of fuses and fuse boxes in his home (Beth's Class Group Discussion) (Bob's Class Group Discussion). The differences in boys and girls motivation was an interesting outcome; in Beth's class the boys were clearly more intrinsically motivated to find out how things worked in the Energy unit. The students at School A were all female and an avenue for future research would be to examine if their lack of intrinsic motivation in Energy was influenced by their gender and the contexts in the resources used to develop the concepts.

The School Context

Many of the differences reported in the above section are related to the very different context of the two schools examined in this study. As described in Chapter 5 and Chapter 6 these schools were very different in many areas, the assertions in Figure 8.19 indicate students concerns at each school. The Researcher feels that the school context has been important in shaping the aims and expectations of the students at that school. Students' aims and expectations have strongly influenced students' enthusiasm, interest and support of the CASSP strategies. The assertions in Figure 8.19 contain two statements reported to the Researcher, unsolicited during the student group discussion and, in the mind of the Researcher, very insightful into the students' expectations and their vision of the purpose of science.

Assertions

The students in School A felt that their current system of science education was successful in helping them to attain grades for tertiary entrance (Assertion 7.2, Chapter 7, Table 7.8).

At School A, the students and parents held strong influential views on the purpose of lower secondary science and the teaching and learning in the science classroom (Assertion 5.2, Chapter 5).

Students at School B expressed concerns about the resources available to them, and were very aware of the inadequacies in their laboratory equipment and text books as well as the state of disrepair of their school building (Assertion 7.4, Chapter 7).

Figure 8.19: Assertions relating to the students concerns regarding issues and facilities in their school context.

In School A, a highly structured and directive teaching and learning style was identified and teachers' actual practice sought to teach many objectives rigidly packed into the science curriculum, with summative assessment driving the learning. Biggs and Telfer (1987) noted that

> highly structured and directive learning causes students to surface learn in order to satisfy the 'schools' needs rather than the deep learning that satisfies ecologically valid needs (p. 516).

School A students found the nature of the current curriculum and assessment allowed them to achieve good grades by surface learning material and consequently make progress into upper secondary science classes. Deeper understanding of the underpinning science concepts was not supported by the present structure of the science syllabus, science teachers and students. Students' aims were to get high grades and better university opportunities, and understanding the science content was considered irrelevant.

In the CASSP study there was an attempt to bring together teaching strategies that promote deeper learning and assessments of understanding rather than recall. Consequently the science in the classroom became more significant and the students were being encouraged to learn and be tested for their understanding of science. Doyle (1983) reported that when learning for understanding students' risk of answering questions incorrectly increased and that these questions were often more ambiguous than basic recall questions. Students at School A were more used to highly defined tasks and memory learning, and were concerned because they did not want to risk answering question incorrectly. They spent a large proportion of time seeking to clarify assessment tasks and were more attentive when seeking information they thought related to assessment items that would influence their grades (Doyle, 1983). Ann's students became particularly frustrated when she did not respond to their answers, as this increased the ambiguity and made it more difficult for students to determine what material to attend to. There were several occasions when student questioning relating to clarifying task requirements interfered with the flow of her lesson and as a consequence of this, she attempted to increase the flow of her lessons by increasing the amount of task information she provided to students thus reducing the ambiguity. Doyle (1983) describes how teachers are often tempted to increase the memory or rote aspect of a task in order help students complete tasks and reduce the management issues that can arise when students struggle in the classroom. Doyle (1983) suggests that students put pressure on the teacher to maintain the stability and predictability of the classroom, even down to how the tasks are designed and presented as this simplifies the task of identifying task-relevant information.

The students in Amy's class performed more poorly in their topic test as it was designed to assess students' understanding, rather than their ability to recall. Consequently, students in Amy's class felt that not only was the science that term more challenging and difficult, they had received lower grades and many of them were still unable to see the value of the science in their everyday lives (Amy Student Discussion Group). Teacher A2's high achieving class were reluctant to participate in the trial, petitioning the science department as they felt the CASSP trial would impact negatively on their ability to achieve good grades. Teacher A2 seemed pleased by this outcome, as it vindicated her decision earlier in the trial not to seek to make changes to her practice. Doyle (1979) predicted that high achieving students such as those in Ann and A2's class have a greater influence on teachers than other students.

School A and its parent community judged its success by the number of students completing upper secondary subjects and gaining tertiary admission. There was so much emphasis by teachers, administration and parents on achieving good grades regardless of the underlying understanding of the objectives that it is unlikely that students would ever want to embrace this trial. Research has shown that without the students' support and the convergence of teachers' and students' expectations, there is little or no chance of sustained changes to teachers' practice (Doyle, 1979, 1990).

School B was a low socioeconomic school and many of the students did not seem to have mapped out clear pathways through the education system. These students embraced the CASSP project being focused in the moment for the experiences and information they were learning. These classes were genuinely interested in many of the topics that Bob and Beth discussed in the class, Many members of Bob's class reported being very impressed by his depth of knowledge in many areas as previous to this they thought he could only read science from their textbook.

Students in this school were hampered by different constraints to the students in School A. School B was a very poor and old state run school in a low socio-economic area. Students at this school often had other concerns to consider more pressing than the science they were learning in their classroom. Some students in the school had suffered physical abuse and had social and/or emotional problems and teachers reported a problem with fighting within the school and high truancy levels. Unlike the students at School A, these students were not focused on long term academic goals.

School B was in a very dilapidated state with windows broken and unable to be opened, computers not working, carpets threadbare and equipment lost and broken. It was hard for these students to feel valued when the textbooks they are given to work with were torn with pages missing and covered with graffiti. They asked whether the CASSP project would be improving their school resources; i.e. their poorly resourced classroom and their lack of new materials.

In conclusion these were very different schools, both existing in the same city of Australia and yet vastly different, with different aims and expectations and students with very different focus. The CASSP project impacted on the schools in different ways. In School A it provided students who were very used to learning for rote and were very task orientated with strategies and assessment to help them learn for understanding. In School B the students were enthused about being given their own materials, rather than sharing incomplete class textbooks. The students were less motivated by assessment and tests than in School A and the CASSP resources and strategies fostered an increased interest in science in many students. The CASSP resources incorporate a degree of flexibility and choice and this helped the program to facilitate different changes at the two schools. It is hoped that this flexibility will help teachers develop learning pathways enabling them to implement CASSP into a wide variety of classroom environments and satisfy different learning needs.

Summary

- Teachers understood the importance of students being motivated and engaged in science, and consequently were interested in student engagement. Students were more motivated and engaged in science during the CASSP trial than students interviewed in Goodrum, Hackling and Rennie's (2001) national review.
- The CASSP strategies promoted deep and comprehensive learning, and these strategies and this learning style was generally rejected by students at School A. These students were more often extrinsically motivated surface or strategic learners, learning only what they deemed necessary in order to pass the test, and the assessment at School A reinforced these methods of learning. The students at

School B embraced the CASSP strategies and were more intrinsically motivated and often experienced deep learning.

- School A and School B were contextually very different from each other. School A's focus was on student achievement and reaching tertiary level education, and in many cases the actual science contents learnt was irrelevant to the students and only the grade was important. School B's students had many other concerns in their lives more pressing than the learning of science, and needed to address these before being able to focus on science in the classroom.

Chapter Summary

The four themes that were the focus of this discussion chapter converged to seek answers to the questions regarding the success of the CASSP project.

Theme one addressed teachers' expressed beliefs about teaching and learning which were similar to current curriculum research ideologies, however, they were not translated into action, due to teachers' previous unwillingness to make the major changes to their practice. Teachers were aware that their practice was not ideal and most teachers were able to identify the pathway to their ideal practice, recognising the major limiting factors that constrain them reaching their goal. These limiting factors were identified as a lack of pedagogical knowledge and for some of the case-study teachers a lack of physics content knowledge related to the Energy topic.

Theme two analysed the case study teachers' experiences of the innovation identified relationships between their concerns, understanding and implementation of the CASSP strategies.

Bob was a Struggler who only utilised and understood the innovation at the lowest levels. He maintained his entrenched beliefs about several of the CASSP strategies and as a consequence he did not implement all the strategies in the CASSP trial. Bob had many classroom management concerns that preoccupied his focus. Amy had reached the highest level of understanding and utilisation of the innovation (Production) and was able to produce her own material. By this standard Amy was the most successful of all the teachers, however, she had used a number of the strategies before the start of the CASSP trial.

Ann had reached the Succeeder level of utilisation of the innovation and was competent in using the materials, but was not totally capable of being independent of the materials. Beth reached a Succeeder level of utilisation of the innovation although she was not competent enough to move away from the materials and produce her own. This research highlighted a relationship between the case study teachers' concerns, understanding and utilisation; it determined that teachers with low level of concerns and low level of understanding of CASSP would have a correspondingly low level of utilisation of the CASSP strategies.

The majority of the Western Australian teachers reported a range of positive changes to their practice over the course of the innovation. Benefits included an increased focus on teaching and learning and a greater understanding of the CASSP strategies. The majority of participating Australian and Western Australian teachers felt that the CASSP project should be continued and many felt the project should be extended into other science areas and age levels.

Theme three examined the factors required to ensure the success of changing teachers practice, these included, time for reflection, modelling and mentoring, curriculum resources to exemplify strategies, available time, leadership within the school, support structures outside the school, a shared vision for teachers, and commitment at the school level. Many of these factors were considered in the design of the CASSP professional learning model and the CASSP resources.

Finally in **theme four** the importance of students and their influence on teachers' ability to make changes to their practice is examined. Students' learning style and motivation are important drivers of students' engagement and achievement and these factors are determined not just by each student and the classroom environment but also by the school context and parental expectation.

While there is a relationship between teachers' changing their teaching and students' increased enjoyment and learning outcomes, other broader aspects of the student study methods as well as the culture or context of the school impinge on the success experienced by the students. As revealed by this research some classes of students were very influential in directing their teachers' practice. If these students did not understand

and support the innovation, then they would undermine the changes the teachers were attempting to make to their practice, and would not increase nor improve their engagement and learning outcomes. Identifying individual students' beliefs and consequently addressing their expectations about science was not attempted during the CASSP innovation. It is speculated here that students must be considered as more integral part of the change process, their beliefs need to be sought and their concerns addressed.

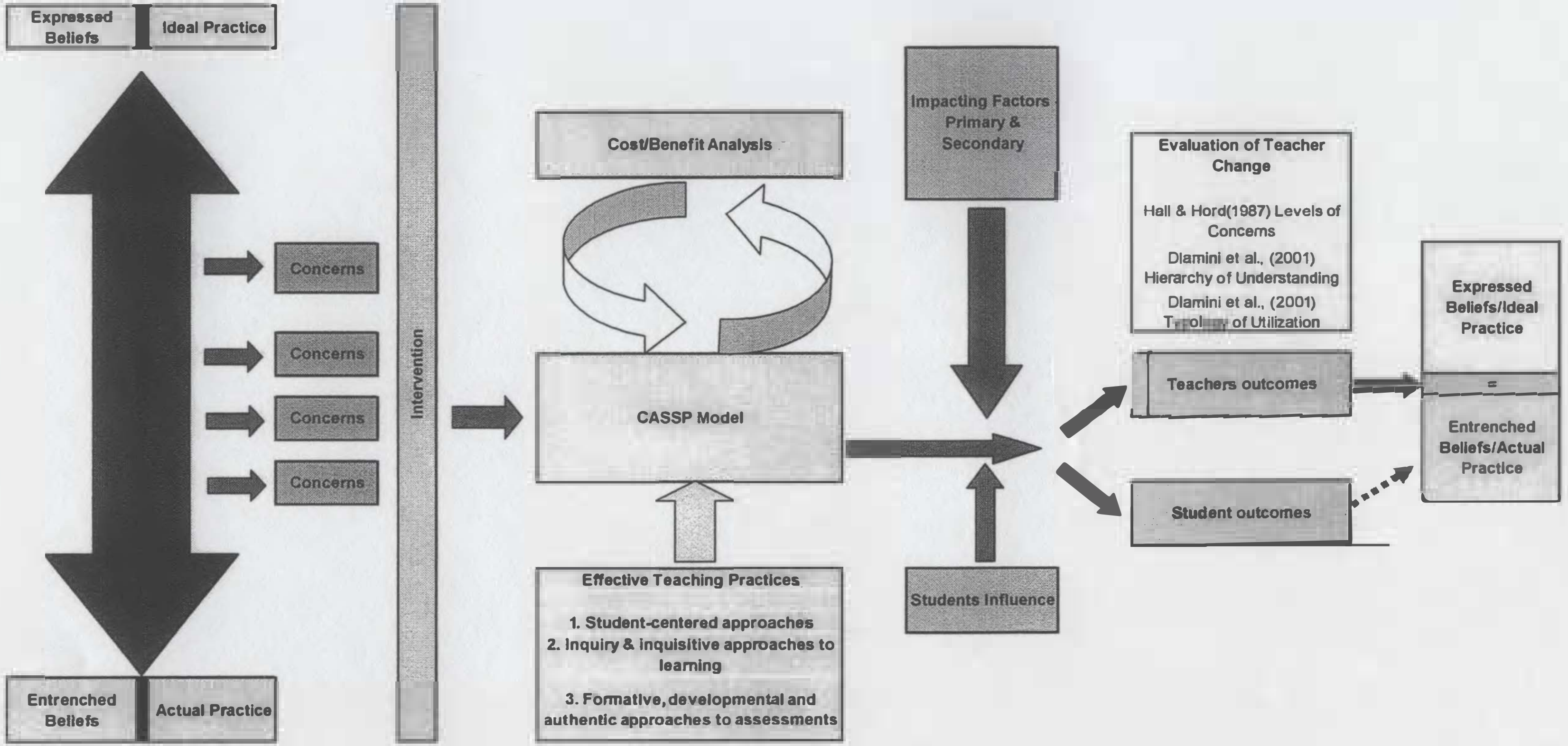

Figure 8.20: Conceptual Framework: Factors influencing teacher change

The conceptual framework is shown in Figure 8.20 in its entirety and maps the pathway of this project as it sought to make changes to teachers' beliefs about the nature of teaching and learning and teachers practice, and the factors that impacted on these change.

This research has highlighted the complexities of teachers' professional. Observations have indicated that the CASSP trial has been successful in instigating changes to teachers' practice. It is hoped that these changes to teachers' practice have initiated an underlying shift to convert teachers' expressed beliefs into manifested beliefs, by addressing many of the constraints teachers felt were impeding their practice. The CASSP project impacted in School A and School B in very different ways. In School A, the CASSP project instigated fierce debate and discussion about the purpose of learning and assessment in lower school science. In School B, the CASSP project provided new and interesting resources and a vast range of contextualised activities. This project identified a number of factors that impacted on the change innovation. The primary factors were addressed by the CASSP model of teacher change; however, the secondary factors demonstrated that the ramifications of the change process extended into the wider school community and to higher levels of the education system.

Finally teachers' practice impacts students' learning, but this relationship is impeded by a number of factors such as the motivation and learning style of the students and the wider school context. The learning styles of the students and the school context have complex, and extensive influence on the science classroom. More significant changes to teachers' practice require understanding and support from students; other school members, including the principal, head of department and peer teachers; and other members of the education community, including state and territory education officers. As determined by Bybee (1997) and Loucks-Horsley et al. (1998) extensive innovations such as this project, designed to change teachers' beliefs and consequently their practice, involve not just the classroom teacher but the entire school community.

CHAPTER 9: SUMMARY, CONCLUSIONS AND IMPLICATIONS

Chapter Overview

This final Chapter develops conclusions from the research and, seeks to answer the research questions regarding the impact of the CASSP trial in promoting teacher change. The Chapter also considers implications for increasing the effectiveness of the CASSP teacher professional learning model.

This Chapter is organised into four sections. The first section, **chapter overview**, provides an overview of this final chapter and a summary of the organisation of the thesis. The second section, **results summary**, provides a summary of results. The third section, **conclusions**, draws the conclusions from the research that answer the research questions. The fourth and final section, **implications**, discusses the implications of the study in terms of teachers' professional learning and areas for further research.

This thesis comprises nine chapters with Chapter one providing a general overview and background of the study with an overarching question summarising the primary purpose of this study and subsidiary questions forming the framework on which the thesis is constructed. Chapter two focuses on the literature to determine why teachers need to change their practice, the characteristics of effective teaching and learning, the importance of teachers, the nature of teacher professional learning, and models used to facilitate and monitor change. Chapter three describes the methodology utilised in investigating teacher change and considers the limitations of the study. Chapters four to seven form the body of results: Chapter four reports the findings of the three teacher questionnaires, Chapter five reports the experiences of the two case study teachers at School A, Chapter six reports the experiences of the two case study teachers at School B, and Chapter seven reports the students' experiences during the trial. Chapter eight uses the assertions identified in the results chapters to assemble the findings around four major themes, which are discussed and interpreted in terms of previous research reported in the literature.

Results Summary

The research has been summarised into the four major themes. Theme one considers teachers' beliefs about their ideal and current practice and the concerns created by the discrepancy between these two sets of beliefs. Theme two considers teachers' experiences while participating in the CASSP trial while theme three identifies and examines the impacting factors that influence the success of the trial. Theme four considers the importance of the students and their impact on teachers' practice.

Theme One

Theme one is comprised of four sections; teachers' beliefs about their actual and ideal practice, the constraints teachers have identified as impacting on their practice and preventing it form being ideal, teachers concerns about their practice and finally teachers' readiness to make changes to their practice.

Teachers' beliefs recognised that lower secondary science is pivotal in helping students to make informed choices and decisions about their world (Assertion 4.1, Chapter 4, Table 4.4), and they advocated that students need to be interested, motivated and enthused (Assertion 4.2, Chapter 4, Table 4.5). Teachers accepted that teaching is a complex, multi-faceted role, requiring teachers to possess a wide range of skills to help students become more independent, inquiry-based learners (Assertion 4.3, Chapter 4, Tables 4.5, 4.6).

This study revealed that the majority of teachers verbalised expressed beliefs that reflect the aims of ideal science teaching and learning. They acknowledged that these expressed beliefs were not translated into action and this is due to a number of factors, which they identified as limiting or constraining their current practice. These constraints, identified in the questionnaire and confirmed by interviews with the case-study teachers, include poor student attitude, limited science resources and curriculum restrictions (Assertion 4.5, Chapter 4, Table 4.11). The case study teachers identified a number of other constraints including their own lack of pedagogical skills, content knowledge and pressures of teaching to an end of topic test that prevented their classroom practice from being ideal.

The discrepancy between teachers' ideal and their actual practice created concerns for teachers about their effectiveness in the classroom. Concerns are pivotal to a change process, without creating and using teachers' concerns, professional learning programs would never have the impetus to create change and would have little or no impact.

There is an assumption that teachers will be supportive of any changes introduced to their classroom and want to adopt any new innovations. This may not always be the case, as research in the health field has identified that professionals participating in the change process must identify a need to make changes to their behaviour to see that adopting the change would give them significant benefits and these benefits would outweigh the extra work and effort required to make them (Prochaska et al., 1994). In this innovation, teachers needed to see the benefits of making changes to their practice, and the professional development sessions were used to create strong concerns for teachers about the discrepancy between their actual practice and their ideal practice. These concerns would help teachers decide that there would be more to be gained in adopting new practice and consequently they would attempt to make changes to their teaching practice.

Case-study teachers Ann and Amy at School A were very supportive of the inquiry-based constructivist strategies, with Ann acknowledging her practice was not ideal and welcoming the proposed changes to improve the quality of student learning. Amy reported she was familiar with many of the inquiry-based strategies and was pleased to be reminded. Not all School A staff were supportive of the changes, Teacher A2 was strongly opposed to the changes proposed by the CASSP program. A2 had weighed-up the pros and cons associated with the change process and decided that the amount of work required was greater than the perceived gains to her and her practice. A2 also had strong entrenched beliefs about needing to cover content to prepare students for tests and upper secondary science, so she did not attempt to adopt the strategies in the CASSP trial. Bob was far more pre-occupied with managing student behaviour and therefore did not have strong concerns about adopting constructivist and inquiry-orientated strategies.

Theme Two

Theme two examined the progress of the case study teachers through the CASSP trial, using classroom observation and teacher interview to map their concerns and their understanding, in order to determine their use of the CASSP strategies. Questionnaire data from the cohort of Western Australian trial teachers' provided insights into the impact of the program on their practice.

Amy, an experienced teacher had few initial concerns about the innovation and was able to reach Production, the highest level of understanding (Dlamini et al., 2001; Hall & Hord, 1987). She was able to become independent of the curriculum materials and was able to synthesis her own materials towards the end of the trial, reaching an Innovators level of use (Dlamini et al., 2001; Hall & Hord, 1987) (Table 8.2).

Ann was an experienced teacher, however, was constantly reviewing her effectiveness and consequently her concerns related to her impact in the classroom. During the trial she progressed through a number of levels to demonstrate a Utilisation level of understanding (Dlamini et al., 2001; Hall & Hord, 1987). She persevered with the trial and towards the end achieved a Succeeder level of use (Table 8.2).

At the beginning of the trial, Bob's focus was not related to the innovation. He was the least experienced teacher and he had a large number of concerns relating to classroom management and time management. He had few concerns about the CASSP strategies, demonstrated a very low level of understanding of the strategies, being only able to identify a few of the strategies. His reluctance to change his behaviour and teach explanation after experience indicated his entrenched beliefs remained unchanged by the CASSP innovation. Consequently he was at a Perception level of understanding and at a Struggler level of utilisation (Dlamini et al., 2001; Hall & Hord, 1987) (Table 8.2).

At the start of the trial Beth reported a number of concerns about her class that were unrelated to the trial. Over the course of the trial, she became focused on the strategies embedded in the trial and consequently demonstrated a Utilisation level of understanding and a Succeeder level of use (Dlamini et al., 2001; Hall & Hord, 1987) (Table 8.2).

At the end of the trial, the majority of the Western Australian teachers indicated they had made changes to their practice. Results indicated they were more inclined to take ownership of the trial materials and use more student-centred strategies. Teachers were comfortable to adapt the materials to suit their students' abilities, and encouraged students to choose activities and progress at their own rate. These findings demonstrated an increased confidence and a deeper understanding of the CASSP materials (Entwistle, 1981). Other benefits that teachers reported included increased reflection on their classroom practice and related pedagogy, and increased collaboration with their peers (Assertion 4.8, Chapter 4, Table 4.36; Assertion 4.9, Chapter 4, Table 4.37).

Theme Three

Theme three examined the factors, which impacted on the success of the project. A number of these factors had already been considered and incorporated into the design of the CASSP model, and were highlighted in this study as primary factors.

Time for reflection, explanation and modelling of new strategies and exemplification of new strategies were all considered as vital for the success of the innovation by the designers of the CASSP model and were designated as primary impacting factors. These factors formed the three integrating components of CASSP. Participative inquiry provided the reflection time to encourage teachers to consider and discuss their classroom practice with their peers (Reason & Bradbury, 1994). The professional development component of the model explained and modelling the CASSP strategies, and the curriculum resources exemplified how the strategies could be integrated into a coherent program of work. These three factors were identified as the drivers of the change process (Goodrum et al., 2003).

The remainder of the factors identified by this study formed the secondary impacting factors. Providing teachers with sufficient time to reflect on their beliefs and practices, experiment with new strategies and embed these changes into their practices was a significant secondary factor identified by this research and many others as important in instigating teacher change (Bybee, 1997; Hall & Hord, 1987; Loucks-Horsley et al., 1998). In fact, as Bybee (1987) ascertains the larger the innovation, the more risky the undertaking and the more time and resources required. The CASSP innovation included a large number of teachers and attempted to make significant changes to their beliefs and practices, consequently providing sufficient time to implement the innovation was imperative.

Other secondary factors that were identified in the study included the significant figures that were identified as influential to the classroom teacher. These included the school project leader (for the most part the Head of the Science Department), the school executive, the CASSP project director, the State and Territory Education Officers, the school principal and participating teachers' peers. Support from these individuals was identified as invaluable in helping the classroom teacher negotiate the change process. This study outlined how these figures impacted on the project and on individual teachers in Schools A and B.

Theme Four

Theme four examined students' interactions with their classroom teacher and how their expectations, motivations and learning styles impacted on the success of the CASSP professional learning program. Students were more motivated and engaged in science during the CASSP trial than students surveyed in Goodrum, Hackling and Rennie's (2001) national review. This theme recognised that there are different motivations that drive students and students may achieve good grades through extrinsic motivation and strategic learning style but not be intrinsically motivated and consequently not engaged in science (Doyle, 1983; Entwistle, 1981).

This theme determined that the students at both case study schools were very different learners with differing motivations and learning styles. This resulted in the project impacting differently on the two schools.

As the CASSP strategies promoted deep and comprehensive learning, and these strategies created concerns for students at School A. These students were more often surface or strategic learners, learning only what they deemed necessary in order to pass the test. The assessment at School A reinforced this mode of learning, making changes very difficult. Students at School A sought to achieve good grades and reach tertiary level education without seeking to truly understanding their classroom science. The students at School B embraced the CASSP strategies and were more intrinsically motivated and often experienced deep, comprehensive learning. These students often had many other more pressing concerns in their lives, and needed to address these concerns before being able to focus on science in the classroom.

Conclusions

What impact does the CASSP program have on teachers' beliefs and practices, and what factors influence these changes?

This overarching question provided the major focus of this thesis as it sought to examine the impact of the CASSP model on teachers' beliefs and practice. The subsidiary questions focused and directed the study and the thesis conclusions are drawn in relation to each question.

1 What beliefs about teaching, learning and assessment did teachers bring to this study?

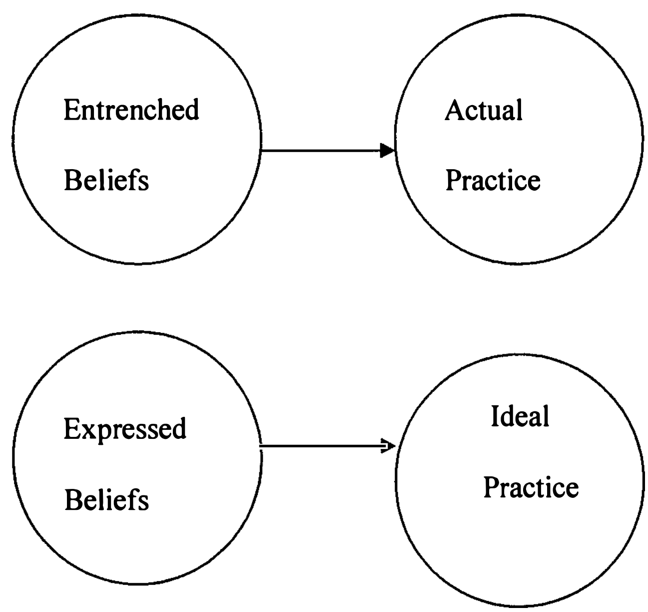

Figure 9.1 A simplified representation of the two sets of beliefs, entrenched and expressed, showing how these beliefs relate to ideal and actual classroom practice.

This study revealed that teachers have more than one set of beliefs about teaching and learning. Keys (2003) research indicates that teachers hold entrenched beliefs which form the basis of their current actual classroom practice and expressed beliefs which they articulate at interviews, but are not translated into practice. The CASSP research determined that these expressed beliefs related to teachers' ideal practice and mirrored ideological beliefs consistent with science education researchers (Figure 9.1). The CASSP research also determined that although teachers were enthusiastic to share their expressed beliefs they were more reticent in examining their entrenched beliefs (Figure 9.1).

At the commencement of the CASSP program in teacher questionnaire one Western Australian teachers articulated expressed beliefs that teaching secondary science was vital in helping students to make sense of the world around them, and expected students to be enthusiastic, interested and motivated to participate in classroom activities (Assertions 4.1, 4.2) (Table 4.8). Their expressed beliefs related to their views of ideal science, they envisaged science that was more contextualised to students' everyday experiences, with more investigative group work and time made available to assess students' prior learning experiences and provide formative feedback (Assertion 4.3). Western Australian teachers' entrenched beliefs about their current practice indicated it was too teacher-centred with the major focus on completing the content and summative assessment (Table 4.9). They also indicated they spent too much time giving notes to students or having students work individually from their textbooks (Table 4.9). Some teachers' entrenched beliefs determined that for some teachers the major focus was on preparing students for upper secondary science and then tertiary education (Table 4.4).

During the trial case study teacher, Beth expressed beliefs that her role in her ideal classroom was one as a facilitator of learning although she acknowledged that her current role was more of a director of student learning (Beth, Interview one 27/7/02). Amy believed that the improvement of the scientific literacy of her students was an important function of her teaching although she also believed that in the context of her school, preparing students for upper school science was also important (Amy, Interview one 27/7/02). Through his interviews and practice Bob expressed entrenched beliefs about the importance of explanation before experience, and these beliefs remained unchanged over the course of the CASSP trial. Teacher A2 at School A initially expressed beliefs that supported all CASSP strategies. Over the course of the trial, however, she demonstrated entrenched beliefs about the importance of teaching and assessing students to meet strident targets to gain entry into upper school science. These entrenched beliefs remained unchanged over the course of the CASSP project.

2 What concerns about teaching, learning and assessment did teachers have at the beginning of the innovation? How did the innovation specific concerns change for case study teachers during the implementation of the CASSP program?

At the beginning of the Western Australian trial teachers expressed beliefs about the ideal science they were striving for and their current classroom practice. These teachers recognised the disparity between their current classroom practice and ideal practice (Tables 4.7, 4.8 and 4.9). Teachers determined that there were a number of constraints, which prevented their actual practice being ideal. The main constraints included poor student attitude, limited science resources and curriculum restrictions (Assertion 4.5). Teachers reported that their major concern related to the effectiveness of the teaching and learning strategies they were currently utilising in the classroom. Other concerns related to students' motivation and the range of students' ability within the class and also the time available for the preparation and running of science classes (Assertion 4.6). The case-study teachers also identified students' lack of literacy skills, the pressure to teach to the topic test, their own lack of specialised physics knowledge and high parental expectations about students' learning and achievement (Amy, Interview One, 22/7/02). It was necessary for the CASSP professional learning program to emphasise teachers' initial concerns, as it is by exacerbating these general concerns about their classroom practice that encourages participating teachers to seek to make changes to their practice.

In conclusion teachers did identify a number of factors which acted to constrain their effectiveness in the classroom. Consequently teachers experienced a number of concerns related to their effectiveness in the classroom, mostly relating to their utilisation of appropriate teaching and learning strategies.

Concerns about the inquiry-based strategies embedded in the program formed an important dimension of the models used to evaluate the CASSP professional learning program (Dlamini et al., 2001; Hall & Hord, 1987). At the start of the project all Western Australian teachers expressed their overwhelming support for the strategies embodied in CASSP program (Table 4.12). A number of teachers, however, expressed concerns about the logistics of implementing these strategies, citing lack of time and appropriate resource as initial concerns.

During the innovation the study examined the case-study teachers' concerns about the CASSP program. Initially most of the case-study teachers experienced logistical or management concerns relating to the implementation of the CASSP strategies into their classroom. These concerns were specifically related to the time management of activities in the classroom, the relationship between the CASSP activities to the existing curriculum and at later stages to assessment.

As reported in Chapter 5, there were numerous heated debates at School A during and at the end of the CASSP trial over the assessment aspect of CASSP. Several participating teachers sought to retain the numerous assessment items covering a wide range of syllabus content, rather than using a smaller number of items that probed deeper understanding of a few key concepts. Teachers were concerned that leaving out any science objectives would result in students being disadvantages in future years.

At the end of the trial, two of the teachers' concerns had become Consequence concerns, relating to the impact the CASSP strategies were going to have on their students learning. During the trial, Bob did not have any concerns that related to the innovation; his concerns were related to student behaviour and time management due to his inexperience in the classroom.

In conclusion the case study teachers experienced changing concerns about the innovation throughout the CASSP program. These concerns mapped by Hall and Hord's (1987) Concerns-Based change model started for the majority of the case study teachers as Management concerns regarding the logistics in time and resources management relating to the implementation. By the end of the study teachers concerns related to the impact of the innovation of the CASSP program on the classroom students and the wider school community. The exception to this was Bob, whose concerns throughout the trial were focused on outside concerns of time and student management issues.

3 To what extent do teachers understand the theory, philosophy and teaching practices associated with the innovation?

Teacher understanding and subsequently their success in implementing the CASSP change innovation was only examined in depth with four case-study teachers participating in this trial using the scale developed by Dlamini, Rollnick and Bradley (2001). Consequently all conclusions drawn here are limited to these four teachers and it can only be speculated how the conclusions would relate to the other participating teachers.

The understanding of the innovation varied a great deal among the four case study teachers in the CASSP trial. Amy was already familiar with many of the CASSP strategies and she demonstrated the greatest understanding at a Production level (Dlamini et al., 2001). She was able to work independent of the supplied curriculum materials and adapt and synthesis other materials to incorporate these strategies. Amy was particularly visionary in her view, seeing the CASSP program as a vehicle for the inquiry-based constructivist strategies.

Ann and Beth were initially only able to recognise the new approach as being different from the old one, however, over time were able to identify the strategies within the materials. This resulted in them reaching a Utilisation level of understanding (Dlamini et al., 2001).

Bob was generally unable to see the difference between the new approaches from the old ones, and only occasionally did he appear to identify a strategy. He showed the lowest level of understanding and seemed only aware of the new written curriculum materials rather than the underpinning strategies. Some of his entrenched beliefs, as seen in an earlier section, remain unchanged throughout the CASSP project.

4 How successful were teachers in implementing the innovation?

In examining the Western Australian teachers' success in implementing the CASSP strategies, the Researcher relied on the experiences of these teachers as reported in the final teacher questionnaire. Many Western Australian teachers reported that the CASSP professional learning program brought about changes in many aspects of their teaching practice. Teachers saw themselves as more effective in the science classroom and reported classroom practice that was directed towards more investigations, with a stronger focus on inquiry-based group work and group discussions (Assertions 4.8 and 4.9). Teachers also reported students were given more independence as learners, at same stages during the trial being able to choose their activities and progress at their own rate (Tables 4.32 and 4.33). Teachers believed many students had enjoyed being involved in the science unit and had in some cases become more independent learners with better group skills and a greater understanding of the concepts (Assertion 4.10). The vast majority of Western Australian teachers supported a wider implementation of the trial.

By examining the case study teachers a link between teachers' concerns about the innovation, teachers' understanding of the strategies in the innovation and teachers' utilisation of the innovation was established in this study. It was determined that the greater the level of understanding of the innovation that teachers reached, the greater the teachers' use of the innovation. It was also found that the level of teachers' concerns also related to the teachers' level of use of the innovation.

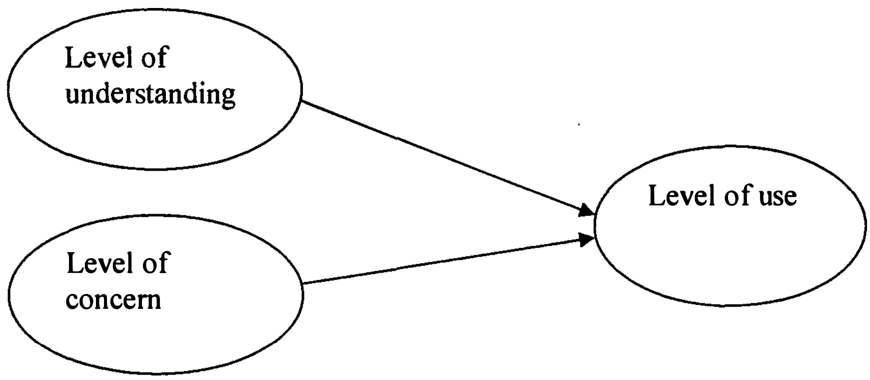

Figure 9.2: Relationship between concerns, understanding and utilisation.

To determine how successful the case-study teachers were in implementing the innovation, the levels of concerns and understanding should be considered. As a result a highly experienced teacher, like Amy, demonstrated the greatest understanding of the innovation, had high level Consequence related concerns and consequently was able to utilise the CASSP strategies to a higher level. She was classified as an Innovator, able to synthesis her own material independent of the CASSP resources (Tables 8.1, 8.2, Chapter 8) (Dlamini et al., 2001). Ann and Beth had concerns relating to their management and consequences of the CASSP strategies on their students. They were Succeeders, successfully using the approach with understanding but unable to be independent of the curriculum resources (Tables 8.1, 8.2, Chapter 8) (Dlamini et al., 2001). Bob's concerns related to issues outside of the innovation (ie. classroom management, time and assessment concerns). Bob demonstrated the lowest level of understanding, had few concerns relating to the CASSP strategies, and consequently he demonstrated the lowest level of implementation of the CASSP strategies. Bob was classified as a Struggler, using the material at a very mechanical level (Tables 8.1, 8.2, Chapter 8) (Dlamini et al., 2001).

5 What factors inhibit or facilitate a change in teaching practice?

There were a number of factors that have been identified as impacting on the process of teacher change. These primary factors were incorporated into the CASSP model and included; time for reflection provided through participative inquiry, explanation and modelling of new strategies provided through professional development, and exemplifications of the strategies provided through the curriculum resources. The developers of the CASSP model considered these factors to be essential for facilitating teacher change. This research supports the developers' assertions about the significance of these components in supporting and nurturing teacher change (Assertions 4.7 and 5.3).

The other factors, designated secondary factors in this study are also significant to the change process, these include; time, leadership, peer support, the support and participation of students, commitment and support by the school administration, and support structures outside the school.

This study found time to be a significant factor in the change process. The CASSP trial was carried out over a 10-week, one term period and it was only after the mid-term professional development that many of the teachers began to understand the significance of the new strategies. It is speculated that further time would have been beneficial to enable teachers to gain more experience using the CASSP model and becoming more familiar with the inquiry-based strategies. As Bybee (1997) states there has to be a balance between extra time and the increase in costs which accompany it. Goodrum et al.'s (2003) report indicated that the majority of teachers supported extending the project, but a few teachers were concerned about how this would impact on the time available for aspects of their teaching.

Leadership was found to be a significant factor in the change process. Teachers who felt guided and supported by the school project leader were more likely to participate and remain involved in the CASSP project. Leadership from within the school administration was also found to be a significant factor in aiding the change process. In School A, the Principal was very supportive of the professional learning program and consequently the teachers felt valued and that their hard work was acknowledged. In School B, however, there was limited support from the project leader and the school administration. Teachers at this school felt more isolated and that their efforts were not being acknowledged. Hall and Hord (1987) argue that teachers in a leadership capacity and principals could be very effective change facilitators. These findings were supported by research by Loucks-Horsley et al. (1998) and Deakin University Consultancy and Development Unit Faculty of Science (2003) *Science in Schools Research Project* (Assertions 5.2, 5.5, 6.3 and 6.4)

Support structures outside the school were also seen to influence the change process. The CASSP external facilitator directed the professional development sessions and provided opportunities for reflection and discussion with participating teachers. The State Science Curriculum Officers provided an official imprimatur the project. Other less significant external support included a web notice board where teachers could talk online about aspects of the project to other teachers, sharing experiences and seeking help, and an assessment site where teacher could find suitable assessment items.

6 What are students' attitudes towards the innovation and what are students' attitudes towards science?

In their surveys and group discussions, students reported very mixed feelings towards the CASSP innovation. Amy was the most successful teacher in the case-study CASSP project, but found students from her girls-only class reported that they found the physical science Energy topic that term for the most part irrelevant and uninteresting. These students did not want to understand the classroom science but rather were more concerned about achieving good grades so their could move into mainstream Year 9 science. These students along with those in Ann's class were identified in the study as being extrinsically motivated by their peers and parental pressure and used to rote learning large numbers of science facts. These students liked the course and assessment they worked on before the CASSP trial as they knew what the expectations were and how to attend to information in order to do well. Students in School A undermined the teachers' efforts to make permanent and effective changes to their classroom practice and as Doyle (1980) noted they often have the power to persuade teachers to change their teaching practice. Ann reported that she believed students had benefited from the topic, although she was aware that students in her class had struggled to gain a deeper understanding of ideas and become more independent learners (Ann, Interview two, 30/8/02).

Students in Bob's class reported that the science had improved during the CASSP trial and they had taken less notes and their real world examples had been mainly interesting and relevant. The majority of students from Beth and Bob's classes were found to be more interested in understanding the science and less focused on the assessment. Although the girls in Beth's class reported that they did not enjoy and were not engaged in the physics unit, preferring biology based units.

Implications

This section examines implications in for teachers' professional learning and implications for further research.

Implications for Teachers' Professional Learning

This research has identified that teachers' professional learning is a very complex process involving a large number of factors. The Conceptual Framework (Figure 8.20) highlights these factors and maps the professional learning journey of teachers when participating in the CASSP innovation. These factors include: considering teachers' expressed and entrenched beliefs about science teaching, learning and assessment; creating a climate for change by highlighting teachers concerns about their practice; examining the primary impacting factors which form the crux of the CASSP model; identifying the secondary impacting factors; and, examining the impact of students on the change process.

Primary factors include the explanation and modelling of the inquiry-based strategies to participating teachers (professional development), incorporating examples of the strategies into exemplary curriculum resources, and setting aside time for teachers to reflect on their classroom practice (participative inquiry).

An important secondary factor is ensuring that the innovation is implemented over a suitable timeframe to give teachers' time to reflect and implement strategies and seek help and guidance (Bybee, 1997; Kotter, 1995; Loucks-Horsley et al., 1998). Australian teachers participating in the trial supported its duration and many suggested lengthening the trial over a longer period (Goodrum et al., 2003).

Designers of future models also need to consider the importance of assigning a suitable leader to encourage and support teachers as they attempt to change their practice. An experienced teacher, possibly the Head of Department would make a suitable person to mentor and guide teachers (Bolman & Deal, 1992; Deakin University Consultancy and Development Unit Faculty of Science et al., 2003). It has also been determined that the school administration plays a valuable role in supporting change, and a principal can be very influential in acknowledging and consequently supporting teacher change (Hall & Hord, 1987). Teachers' peers were also found to be influential in the change process, collaborating in the reflective discussion and supporting their classroom practice. Peers either supported and consequently facilitated change or were obstructive to professional learning. Another secondary factor was the State and Territory Education Officers who provide implicit support and endorsement by the education ministries.

Finally, the importance of the classroom students must be considered. It has been demonstrated by this research that students support or obstruction of the change process can have a significant impact on their classroom teacher. Students must support proposed changes if teachers are to successfully change their practice (Doyle, 1983).

Implications for Further Research

There are a number of questions that remain unanswered and therefore can direct future study in this area. Two areas of further research are represented by the following questions

- How can we encourage more teachers to change their teaching practice?

- How can we encourage students to support their teachers and to actively seek to change their learning?

How can we encourage more teachers to change their teaching practice?

One of the most important implications of a teacher professional learning program is how the study can become more successful, in other words, how can it help more teachers to change their behaviour? In the past change innovations have been implemented in the classroom and the mechanisms of the implementation have not been considered. The innovation is delivered, the teachers participate, the teachers return to their classroom and continue teaching and the impact is often considered but rarely measured (Cuban, 1990; Hall & Hord, 1987).

The first way is by focusing on the differing impact of the study on the four case study teachers, to determine if this may be generalised to the wider teaching population. The second way is to examine the reluctant teachers in the study, identifying the cause of their reluctance and seeking ways to encourage and support them through the change process. The impact of these reluctant teachers extends further than their classroom but also into the classrooms of their peers impacting on their teaching practice.

Case study teachers. Further research is needed to determine how to help those teachers who received the least benefit in participating in the CASSP project. The least experienced teacher in this study Bob was the teacher who received the least benefit from the CASSP project. In this study he demonstrated the lowest level of understanding and consequently was the least successful in implementing the innovation into his classroom. Hall and Hord (1987) had previously identified that teachers in the beginning of their careers experienced a large number of concerns relating to the day to day classroom experiences. Bob experienced a number of concerns about his teaching especially relating to the management of his students' behaviour.

It may be inferred that teachers with more teaching experience may be able to better implement the CASSP strategies and find the innovation more beneficial to their classroom practice. As a consequence further research could be directed at determining if the CASSP project is a more useful model to teachers who have several years teaching experience and have had time to address many of the initial student management concerns relating to their classroom practice (Hall & Hord, 1987).

Reluctant teachers. Further research is also required to determine how to address the needs of the reluctant teachers to encourage them to seek to change their teaching practice. This research identified one such experienced teacher, Teacher A2, at School A. She was extremely reluctant to participate in the CASSP trial although because her school had volunteered to participate was unable to withdraw. By the time the project was half way through she was very vocal in her opposition to all aspects of the CASSP trial. She had the opportunity to withdraw from the project but refused, preferring to try to undermine the success of the trial in her school. She professed herself very busy and overloaded and as a consequence the Researcher speculated she did not have sufficient time to attend to the CASSP project.

How then can the CASSP trial seek to address the needs of teachers who are not impacted by this trial? Observation and speculation by the Researcher determined that both teachers A2 and Bob had powerfully entrenched beliefs that remained unchanged throughout the CASSP trial. A2 and Bob also seemed overloaded, with Bob having student behaviour management and time concerns within the classroom and A2 seeming time poor with other commitments outside of the science classroom. It is speculated that if these teachers had fewer teaching and extra curricula commitments and were given extra support they could be encouraged to re-examine their beliefs about teaching, learning and assessment. Further research into identifying these teachers and examining their entrenched beliefs is required, in order to enable them to openly examine and discuss their beliefs and the professional learning initiative offered to them.

How can we encourage students to support their teachers in changing their practice, and to actively seek to change their learning?

In the same way as professional development used to be designed and brought to the classroom door without the input and support of the classroom teachers, teachers and change managers are bringing new innovations to change the way students learn without consulting or involving the students themselves. As this thesis and other research has clearly demonstrated, students have significant influence on their teachers' behaviour and classroom practice and in some cases can exert pressure to influence teachers to change their practice (Doyle, 1983, 1990).

Further research would be required to determine how to acquaint the students with the goals and aims of the change innovation and help them to understand the benefits to them and thus encourage them to support and participate in the change process. By presenting students with the information and encouraging the same process of decisional analysis that is used for teachers, students can become active participants in the change process rather than passive observers. It must be noted that in School A encouraging students to be actively involved in the change process, would be extremely difficult in the current circumstances. It is speculated that the entire assessment process of the science department would need to change to reward the deep, comprehensive learning that the CASSP study sought to achieve in the classroom. It is speculated that pressure against change at School A would most probably come from a number of sources including, teachers, students and parents.

Concluding Comments

This thesis has sought to map teachers' professional learning journeys when participating in the CASSP innovation. As seen in the final Conceptual Framework in Figure 8.20, the journey is a complex process with many factors having been identified as influential to the change process. There are three unique areas have been identified and described by this study. The first area relates to teachers' entrenched and expressed beliefs. The second area examines the relationship between teachers' concerns, their understanding and their use of an innovation (Dlamini et al., 2001; Hall & Hord, 1987). The third area examines the primary and secondary factors and the role of students in impacting on the teachers' ability to change their practice.

In examining teachers' beliefs it was determined that teachers harbour more than one set of beliefs about the nature of science and the purpose of teaching and assessing secondary science (Keys, 2003). One set of beliefs, teachers' expressed beliefs were identified as those views teachers articulated about ideal science teaching and learning, while the other set of beliefs identified by this study as entrenched beliefs reflected teachers' actual classroom practice. This study determined that teachers recognised these beliefs were divergent and sought to shape their entrenched beliefs to become like their expressed beliefs, seeking to mould their current practice into a more ideal practice.

A relationship was identified by this study that related teachers' concerns about an innovation to their understanding and use of an innovation. Previously it was determined that a relationship existed between understanding and utilisation of an innovation (Dlamini et al., 2001), however, this thesis extends this relationship to incorporate the levels of concerns identified by Hall and Hord (1987) (Figure 9.2). It was determined that teachers who have higher level concerns about their teaching and a greater understanding of the new strategies are able to implement and use strategies in the innovation to a more advanced level.

This thesis sought to collate the factors which impacted on the successful implementation of the CASSP innovation. The CASSP model contained primary factors including an explanation and modelling component in the curriculum development, a series of curricular exemplars in the curriculum resources, and time set aside for teacher reflection in the participative inquiry. This thesis found all three of these factors important in helping teachers quest for change. Other secondary factors identified by this thesis, included: providing adequate time for the implementation of the innovation; providing teachers with leadership and support from within their Science Departments; ensuring the School Administration was aware and supportive of the innovation; providing teachers with the knowledge that the State or Territory education department was supportive of teachers efforts to change; bolstering teachers change efforts with personnel and resources from outside the school (External facilitator of the CASSP project, website); encouraging all teachers' peers to be involved with and enthusiastic supporters of teachers' change efforts; and informing the students about how the proposed outcomes of the innovation will impact on their learning, as they have a significant investment in the new outcomes and therefore must support the proposed changes.

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CASSP Project

Teacher Questionnaire 1

Name____
School____

Qualifications and Experience

Qualifications____

What is your science major? (if you have one) __________________

How many years have you taught lower secondary science?______

What is your area of teaching specialisation? __________________

School code		Teacher code	

This questionnaire seeks your opinions, beliefs and concerns about science teaching and learning. Information from these questionnaires will be used to evaluate the success of the CASSP Project.
Information from the questionnaires will be aggregated and summarized for inclusion in research reports. Any statements made by individuals that are included in research reports will use pseudonyms to retain the anonymity of the participants. No individual or school will be identified in any report.
No personal information gathered in this study will be accessible to your science department, school or the Education Authority. The Ethics Committee of Edith Cowan University, Western Australia, has approved this study.

Thank you for you participation in this study.

Teacher Beliefs

Q 1. What do you believe is the main purpose of teaching lower secondary science?

____

____

____

____

____

Q 2. Please use phrases to describe what you believe good teaching and learning looks like in Year 9 science.

a) I believe science teaching is most effective when the teacher does the following

1) ____
2) ____
3) ____

b) I believe science learning is most effective when the students do the following:

1) ____
2) ____
3) ____

Ideal and Actual Science

Q 3. Consider **an ideal** lower secondary science lesson and a typical one of **your actual** science lessons, and determine the relative amount of time spent on the following tasks.

Time allocation	Ideal lessons (%)	Your actual lessons (%)
Teacher explaining to whole class.		
Whole class discussion.		
Group-based practical and activity work.		
Giving notes to students.		
Students working individually including working from the text.		

Q 4. Examine the following statements carefully and decide how they correspond with your views about quality science teaching and learning. Please tick the box that best represents how often these phenomena would occur in an **ideal** Year 9 Science class.

In an ideal Year 9 science classroom	Always occurs	Occurs most of the time	Occurs some of the time	Seldo m occurs	Never occurs
a) The major focus is completing Unit content					
b) The unit is organised around contexts and issues relevant to students.					
c) Students must follow experiment instructions given by the teacher very carefully to reach the correct conclusions					
d) Students plan their own experiments to investigate their own questions					
e) Practical work is used to illustrate the concepts that have been introduced					
f) Practical work is used to provide experiences of phenomena before concepts are introduced					

g) Students work in groups for most of their work					
h) Skills that enhance the effectiveness of learning in groups are explicitly taught					
i) Discussion is not encouraged as a quiet classroom is the most productive					
j) Whole class discussions occur at the conclusion of activities with the main ideas summarized.					
k) Assessment is used mainly for grading and reporting					
l) Assessment is mainly portfolios and work samples to determine where students are at and where to go next.					
m) The reporting of students' progress is in levels for outcomes					
n) Students learn science that is relevant to their lives.					
o) Students prior beliefs are considered when planning lessons					
p) Students have access to computers to research information					

Q 5. Please think about **actual** Year 9 science classes you have taught. Examine the following statements carefully and decide how they correspond with your experiences in the classroom. Please tick the box that best represents how often these phenomena occur in your Year 9 science classes.

In your actual Year 9 science classroom	Always occurs	Occurs most of the time	Occurs some of the time	Seldom occurs	Never occurs
a) The major focus is completing Unit content					
b) The unit is organised around contexts and issues relevant to students.					
c) Students must follow experiment instructions given by the teacher very carefully to reach the correct conclusions					
d) Students plan their own experiments to investigate their own questions					
e) Practical work is used to illustrate the concepts that have been introduced					
f) Practical work is used to provide experiences of phenomena before concepts are introduced					

g) Students work in groups for most of their work					
h) Skills that enhance the effectiveness of learning in groups are explicitly taught					
i) Discussion is not encouraged as a quiet classroom is the most productive					
j) Whole class discussions occur at the conclusion of activities with the main ideas summarized.					
k) Assessment is used mainly for grading and reporting					
l) Assessment is mainly portfolios and work samples to determine where students are at and where to go next.					
m) The reporting of students' progress is in levels for outcomes					
n) Students learn science that is relevant to their lives.					
o) Students prior beliefs are considered when planning lessons					
p) Students have access to computers to research information					

Limiting Factors

Q 6. List four major factors that inhibit or limit the effectiveness of your lower secondary science teaching. (1 = most important)

1) ______________________________
2) ______________________________
3) ______________________________
4) ______________________________

Concerns about Strategies

Q 7. For each of the following strategies that are included in your State's curriculum documents, please explain briefly:

- How **useful** you think this strategy will be in improving teaching and learning?
- Do you have any **concerns** about its implementation?

Strategies

1) Increasing students' interest in science by setting lessons in a real world context.

Usefulness____

____

Concerns____

____

2) The use of formative assessment to give feedback to teachers and students, and to plan for learning.

Usefulness____

____

Concerns____

____

3) Encouraging more student-centred learning.

Usefulness____

Concerns____

4) Use of investigations to promote inquiry in the curriculum

Usefulness____

Concerns____

5) Teaching to promote deeper student understanding rather than superficial recall.

Usefulness____

Concerns____

6) The use of Information Technology to enhance student learning.

Usefulness____

Concerns____

<u>Teaching and Learning</u>

Q 8.a) What, if any, are your main concerns about your own teaching?

b) What changes/improvements would you like to make to your teaching?

Q 9. What do you wish to achieve from this project?

Q 10. What will help/hinder you in reaching this goal?

Q 11. What do you hope your students will gain from the project?

Final Comments. Thank you for taking the time to consider your teaching practice and completing this questionnaire. Please feel free to make any further observations and comments about any other matters, in the space below

Prepared by Rachel Sheffield in consultation with A/Prof. Mark Hackling and A/Prof. Denis Goodrum.

CASSP Project

Teacher Questionnaire 2

Name ______________________________________

School ______________________________________

This questionnaire seeks your opinions, beliefs and concerns about science teaching and learning. Information from these questionnaires will be used to evaluate the success of the CASSP Project. Information from the questionnaires will be aggregated and summarized for inclusion in research reports. Any statements made by individuals that are included in research reports will use pseudonyms to retain the anonymity of the participants. No individual or school will be identified in any report.

No personal information gathered in this study will be accessible to your science department, school or the Education Authority. The Ethics Committee of Edith Cowan University, Western Australia, has approved this study.

Thanks for participating in this study.

A/Prof Denis Goodrum, A/Prof Mark Hackling and Rachel Sheffield

Researcher code – please leave

School code		Teacher code	

<u>How is it going?</u>

Q 1. What aspects of the teaching and learning of the Energy and Change unit this term have been different from previous terms?

Q2. What, if any aspects of the project are you finding particularly beneficial?

Q 3. What, if any aspects of this project are causing you concern?

Curriculum Resources

Q 4. a) What activities have you completed at the midpoint of this term? Put numbers in the left hand column of the table below to indicate all the sections completed so far this term and the order in which you completed them. Please evaluate the usefulness of the sections you have completed by placing a cross in the appropriate column in the table below

Sections Completed	Components of Student Book	Very useful	Useful	OK	Little use	No use
	Light Using Light					
	1 How we see Activity 1 Light rays					
	Activity 2 Shadows					
	Activity 3 Optical illusions					
	2 Reflection Activity 1 Bending mirrors					
	Activity 2 Images					
	Activity 3 Plotting light rays					
	Activity 4 Predicting ray paths					
	Activity 5 Calculations & rays					
	3 Refraction Activity 1 Exploring Prisms					
	Activity 2 Lenses & images					
	Activity 3 Lenses & refraction					
	Activity 4 Refraction & gems					
	4 Colour Activity 1 Cellophane					
	Activity 2 Seeing in colour					
	Activity 3 Making Rainbows					
	Activity 4 Colour and energy					
	Activity 5 Scattering of light					
	Activity 6 What is light?					
	Electricity Making Globes Work					
	Making Electrical circuits					
	Circuits and symbols					
	Controlling electricity					
	Detecting electricity					
	Understanding electricity					
	Making electricity					
	Electrical terms					

Sections Completed	Components of Student Book	Very useful	Useful	OK	Little use	No use
	Electrical Applications					
	Energy What is energy					
	Hot car investigation					
	Energy investigation Solar Energy					
	Wind Energy					
	Electrical energy					
	Mechanical energy					
	Ultraviolet energy					
	Chemical energy					
	Efficiency of energy transformations					

b) How effective were the materials in directing teaching and learning?

Student book

Very effective	Effective	OK	Ineffective	Very ineffective

Why? ____

____

Teachers book

Very effective	Effective	OK	Ineffective	Very ineffective

Why? ____

____

c) What, if any changes would you make to the student and teacher books?

____

____

____

____

Q 5. a) There is far more material in the curriculum resources than can be covered in one, 10-week term. What factors have influenced your selection of activities taken by students?

____

____

____

____

____

b) Have you used the resources to allow different students to work on different activities? Explain

____

____

____

____

____

c) Have you adapted the materials or the approaches for your class? Explain

____

____

____

____

____

Q 6 How do you think the students have responded to the new materials and the learning approach?

Student book and activities

Very positively	Positively	Neither positively nor negatively	Negatively	Very negatively

Learning approach

Very positively	Positively	Neither positively nor negatively	Negatively	Very negatively

Other____

____

____

____

Professional Development

Q 7. The initial professional development encompassed a number of key components. Please comment on the effectiveness of the PD components by ticking the most appropriate response below.

Components of PD	Very useful	Useful	OK	Little use	No use
Cooperative Learning (nuclear reactor game & video)					
Teaching and learning strategies (ie. video on primary electricity lessons)					
Assessment strategies (review of examples)					
Peer presentation (review sections of Light Module and provide a peer review)					
Questioning (types of questions, use of wait time)					
Participative inquiry (types of questions etc)					

Q 8 a) Overall the professional development was

Very effective	Effective	OK	Ineffective	Very ineffective

b) The most useful part of the initial Professional Development was _________

____

____

____

c) How could the initial Professional Development be improved ____________

____

____

____

Participative Inquiry (PI)

Q 9. How has the participative inquiry (PI) been implemented in your school? In the table below, put a cross in the box which best represents what is occurring in your school

Type of Participative Inquiry	Occurs frequently	Occurs occasionally	Occurs infrequently	Never occurs
Informal PI sessions - where the teachers discuss the progress of the project on an ad hoc basis with their colleagues but not as a departmental meeting and not using the PI questions				
Semi formal PI sessions –the CASSP teachers discuss the project at meetings but do not use the PI questions.				
Highly formalised PI sessions - where the liaison person or HOD runs the session at set times using the set PI questions with all the teachers involved in the project.				

Or, is the PI in your school taking some other format? ________________

____

____

____

Q 10. The PI questions were

Very helpful	Helpful	OK	Little help	No help

Q 11. The PI discussions were

Very useful	A little useful	OK	Little use	No use

Q 12. The greatest benefit of the PI discussion is ______________________

____

____

____

Q 13. The PI could be improved by ______________________________

____

____

____

Web site

Have you been able to access the CASSP web site? Yes _____ No ______

Comment

Final Comments. Thank you for taking the time to consider your teaching practice and completing this questionnaire. Please feel free to make any further observations and comments about any other matters, in the space below

Prepared by Rachel Sheffield in consultation with A/Prof. Mark Hackling and A/Prof. Denis Goodrum.

CASSP PROJECT–
TEACHER QUESTIONNAIRE III

Name ____

School ____

This questionnaire seeks your opinions, beliefs and concerns about science teaching and learning. Information from these questionnaires will be used to evaluate the success of the CASSP Project.

Information from the questionnaires will be aggregated and summarized for inclusion in research reports. Any statements made by individuals that are included in research reports will use pseudonyms to retain the anonymity of the participants. No individual or school will be identified in any report.

No personal information gathered in this study will be accessible to your science department, school or the Education Authority. The Ethics Committee of Edith Cowan University, Western Australia, has approved this study.

Thanks for participating in this study.

The CASSP Researchers

Researcher code – please leave blank

School code		Teacher code	

Curriculum Resources

Q 1 a. <u>Since the second PD,</u> what activities have you completed up to the end of this term? Put numbers in the left hand column of the table below to indicate all the sections completed and their order.

Please evaluate the usefulness of the sections you have completed by placing a cross in the appropriate column in the table below

Sections Completed	Components of Student Book	Very useful	Useful	OK	Little use	No use
	Light Using Light					
	1 How we see Activity 1 Light rays					
	Activity 2 Shadows					
	Activity 3 Optical illusions					
	2 Reflection Activity 1 Bending mirrors					
	Activity 2 Images					
	Activity 3 Plotting light rays					
	Activity 4 Predicting ray paths					
	Activity 5 Calculations & rays					
	3 Refraction Activity 1 Exploring Prisms					
	Activity 2 Lenses & images					
	Activity 3 Lenses & refraction					
	Activity 4 Refraction & gems					
	4 Colour Activity 1 Cellophane					
	Activity 2 Seeing in colour					
	Activity 3 Making Rainbows					
	Activity 4 Colour and energy					
	Activity 5 Scattering of light					
	Activity 6 What is light?					
	Electricity Making Globes Work					
	Making Electrical circuits					
	Circuits and symbols					
	Controlling electricity					
	Understanding electricity					
	Making electricity					

Sections Completed	Components of Student Book	Very useful	Useful	OK	Little use	No use
	Electrical terms					
	Electrical Applications					
	Energy What is energy					
	Hot car investigation					
	Energy investigation Solar Energy					
	Wind Energy					
	Electrical energy					
	Mechanical energy					
	Ultraviolet energy					
	Chemical energy					
	Efficiency of energy transformations					

Q2. Which modules have you attempted this term? Please circle the modules below.

LIGHT ELECTRICITY ENERGY

What is your general opinion of the modules you have attempted this term?

____

____

____

____

____

____

____

____

Q3. Please evaluate the teachers' resource book and web site, ticking the most appropriate box in the table below.

	Very useful	Useful	OK	Little use	Poor
Teacher resource book					
Teaching strategies					
Questions in teaching strategies					
Commentary in teaching strategies					
Background information					
Resource sheets					

	Very useful	Useful	OK	Little use	Poor
Web site					
Assessment resources					
Solutions					

Q 4 a) Since the discussion at the second PD, have you used the resources to differentiate instruction within the class, with different students working on different activities? Explain

b) How have you adapted the materials or approaches to make them more effective for your students?

Classroom Practice

Q 4. Please determine which of these strategies have been use more or less frequently in your Year 9 science classroom this term and explain why.

Strategy	**No change**	**I now do more**	**I now do less**	**Comment**
Students copying notes from the board/OHP.				
Teacher explanations				
Small group discussions and activity work.				
Using cooperative groups for class activities				
Using open-ended questions and extended wait time.				
Using more examples that relate classroom science to students real life experiences				
Conceptual explanation developed <u>after</u> activity and experiences.				
Students participate in guided inquiries and open investigations.				
Less concepts are covered but students have more experiences of these.				
Formative assessment is used during the topic.				
Summative assessment is used at the end of the topic.				
Diagnostic assessment is used at the start of the topic				

Q 5. Please consider typical Year 9 Energy unit lesson this term and estimate the time you spent on the following.

Teaching-learning activities	Approx time (%)
Teacher explaining to whole class.	
Whole class discussion.	
Group-based practical and activity work.	
Giving notes to students.	
Students working individually including working from the text.	
Total	100

b). What have been the main differences in your teaching this term?

c) What has been the main difference in students' learning this term?

Participative Inquiry (PI)

Q 6. The meeting and discussing of ideas between science teachers has been found to be extremely powerful in supporting teachers. What sorts of PI meetings have occurred in your school this term. In the table below, put a cross in the box which best represents what is occurring in your school

Type of Participative Inquiry Discussions	Occurs frequently	Occurs occasionally	Occurs infrequently	Never occurs
Informal PI sessions - where the teachers discuss the progress of the project on an ad hoc basis with their colleagues but not as a departmental meeting and not using the PI questions				
Semi formal PI sessions –the CASSP teachers discuss the project at meetings but do not use the PI questions.				
Highly formalised PI sessions - where the liaison person or HOD runs the session at set times using the set PI questions with all the teachers involved in the project.				

Q 7. The PI questions were

Very helpful	Helpful	OK	Little help	No help	Not used

Q 8. The PI discussions were

Very useful	A little useful	OK	Little use	No use

Q 9 a). The greatest benefits of the PI discussions have been

____

____

____

____

b). The PI could be improved by ______________________________

____

____

In summary, how has it gone?

Q10 a) What do you feel has been the purpose of this project?

b) What do you feel you have achieved by being involved in the project

c) What have your students gained from you being involved in this project?

d) Do you think your Year 9 students have enjoyed Science this term?

So, where to now?

Q 11 a) Should this pilot project be extended to provide for more curricula modules?

____

____

b) Should the PD and support be extended over a year rather than a term?

____

____

c) So what PD areas would you include in a project that was extended for a year?

____

____

____

____

d) What would be the most useful format for the curriculum resources in the future?

	Student book	Teacher book
Year book containing a variety of modules (ie Energy) and sub modules (ie. Light)		
Term book (like project) with sub modules		
Small sub module book (ie Light) with activities for 5 weeks.		

e) Would the student book be improved by the addition of any of the following?

	/ X	Comment
Additional reading material		
More web sites		
More challenge activities		
More directed activities		
Equipment lists		
Historical snippets		
Industry case studies		

Final Comments. Thank you for taking the time to consider your teaching practice and completing this questionnaire. Please feel free to make any further observations and comments about any other matters, in the space below

Prepared by Rachel Sheffield in consultation with A/Prof. Mark Hackling and A/Prof. Denis Goodrum.

Appendix 3.2 Instrument Lesson Observation Sheet

Lesson Observation Sheet

	Teacher number Class Date	Time	Lesson (SB) p
Time (mins)	What teacher is doing!	What students are doing!	
Start Opening Lesson	Use of Questions, Links to context, Extent of teacher direction		
Start	Activity description,(strategy used), student engagement & level of challenge		
Start Closing Lesson	Teacher conclusions,		

Specific Learning

- Student centred learning promoting greater student understanding

- Inquiry based learning (investigation)

- Use of effective formative assessment

Teacher Comments

Other Information

Lesson Observation Diary of the Case-Study Teachers Participating in the CASSP trial

Trial details	Date	Details
Week 1	22/7/02	Interview 1 – Ann Interview 1 – Amy Lesson Observation Bob
	23/7/0 2	Lesson Observation Ann Interview 1 – Bob Interview 1 – Beth
	24/7/02	Lesson Observation Beth Lesson Observation Ann Lesson Observation Amy
	25/7/02	Lesson Observation Ann Lesson Observation Amy Lesson Observation Beth
	26/7/02	Lesson Observation Beth Lesson Observation Amy
Week 2	29/7/02	Lesson Observation Ann Lesson Observation Amy
	30/7/02	Lesson Observation Beth Lesson Observation Bob Lesson Observation Amy
	31/7/02	Lesson Observation Ann Lesson Observation Bob PI School B 2.50 – 3.10
	1/8/02	Lesson Observation Bob Lesson Observation Beth Lesson Observation Beth
	2/8/02	Lesson Observation Beth PI School A 1.30 – 2.45
Week 3	5/8/02	Lesson Observation Ann Lesson Observation Amy Lesson Observation Bob Lesson Observation Bob
	6/8/02	Lesson Observation Beth

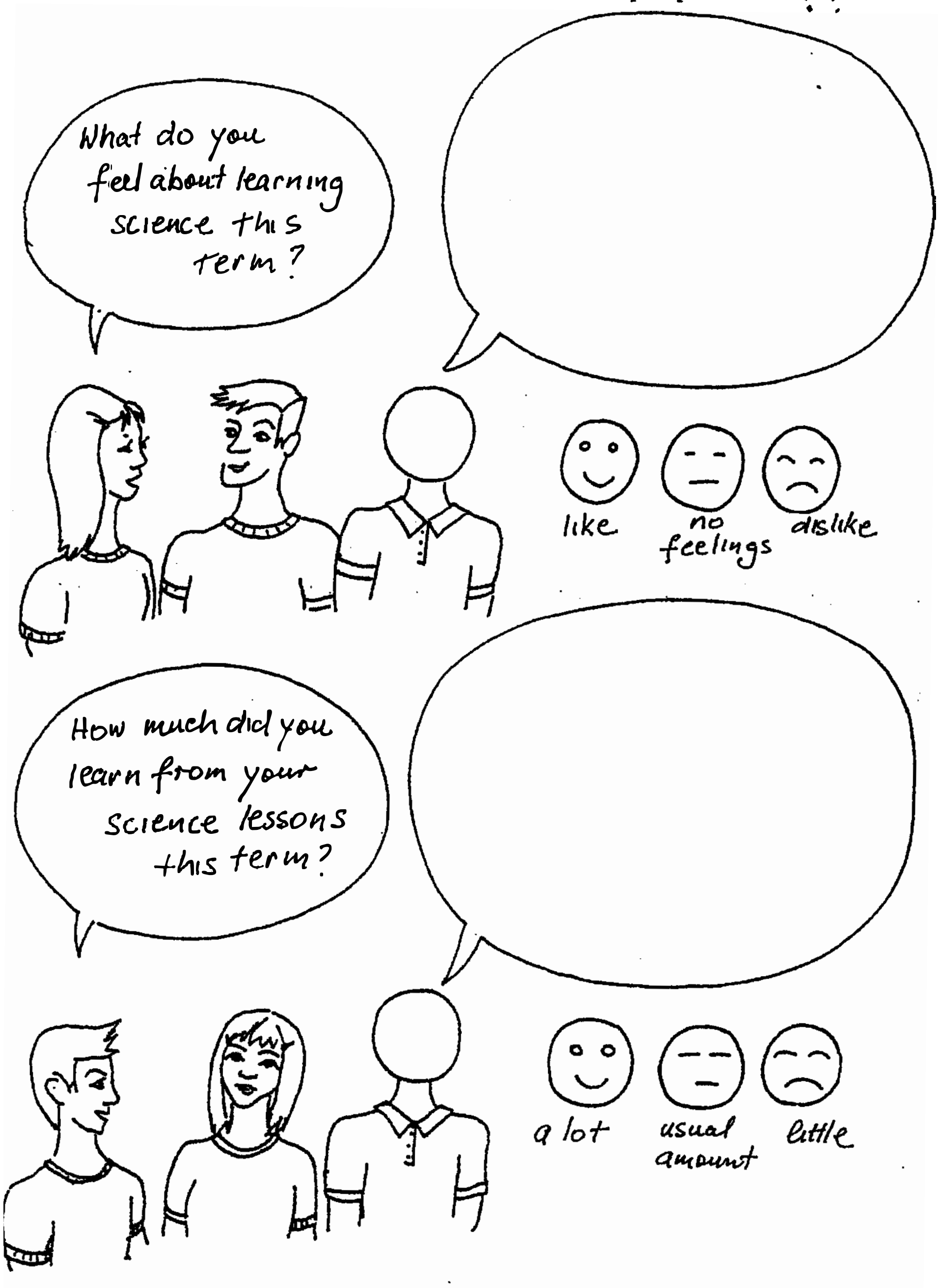
		Lesson Observation Bob Lesson Observation Amy
	7/8/02	Lesson Observation Ann Lesson Observation Amy Lesson Observation Bob
	8/8/02	Lesson Observation Amy Lesson Observation Beth
	9/8/02	Lesson Observation Ann
Week 4	12/8/02	Lesson Observation Amy Lesson Observation Ann
	13/8/02	Lesson Observation Beth Lesson Observation Bob
	14/8/02	Lesson Observation Amy
	15/8/02	Lesson Observation Ann Lesson Observation Amy
	16/8/02	Lesson Observation Beth
Week 5	19/8/02	Lesson Observation Ann Lesson Observation Bob Lesson Observation Bob
	20/8/02	Lesson Observation Beth Lesson Observation Bob Lesson Observation Bob
	21/8/02	Lesson Observation Ann Lesson Observation Amy Lesson Observation Bob
	22/8/02	Lesson Observation Bob Lesson Observation Beth
	23/8/02	Lesson Observation Ann Lesson Observation Amy
Week 6	27/8/02	2nd Professional Development Day
	28/8/02	Lesson Observation Beth Interview 2 Beth Lesson Observation Bob
	29/8/02	Interview 2 Bob Lesson Observation Bob

		Lesson Observation Ann Lesson Observation Amy
	30/8/02	PI School A 9-1 pm Interview 2 Ann Interview 2 Amy
Week 7	2/9/02	Lesson Observation Ann Lesson Observation Amy Lesson Observation Bob
	3/9/02	Lesson Observation Bob Lesson Observation Beth
	4/9/02	Lesson Observation Ann Lesson Observation Amy
Week 8	10/9/02	Lesson Observation Beth Lesson Observation Bob
	11/9/02	Lesson Observation Amy
	12/9/02	Lesson Observation Ann Lesson Observation Amy
	13/9/02	Lesson Observation Beth
Week 9	16/9/02	Lesson Observation Amy Lesson Observation Bob
	17/9/02	Lesson Observation Beth Lesson Observation Bob
	18/9/02	Lesson Observation Ann Lesson Observation Amy Lesson Observation Bob
	19/9/02	Lesson Observation Amy Lesson Observation Ann
		Lesson Observation Beth
Week 10	23/9/02	Interview 3 –Amy Interview 3 - Ann Lesson Observation Ann Lesson Observation Amy PI 3 – Lunch with Administration at School A
	24/9/02	Lesson Observation Bob Lesson Observation Ann

25/9/02	Lesson Observation Beth Interview 3 – Beth Lesson Observation Bob Interview 3 – Bob
26/9/02	3rd Professional Development

Reflections on Science

Imagine you and your friends are discussing your science lessons. If the following questions were asked how would you respond? For each question tick the face that best reflects your response. Then write your reasons in the balloon space provided.



Coding Manual – Questionnaire 1 CASSP Project

On Excel Spreadsheet the following details apply

Column A rows 1 – 25 represents the teachers in WA project

Subject

Subject number	Subject name	Subject number	Subject name
1			

State

Column B- State

1	WA
2	QLDS
3	NSW
4	Tas
5	Vic
6	SA

School

Column C – School

1
2
3
4
5

Qual

Column D – Qualification (Qual)

1	B Sc only
2	3 or 4 years pre-service education including science and education
3	3 or 4 years pre-service education including education but not science major
4	Masters degree in education
5	Masters degree in science

Maj

Column E – Major Qualification (Maj)

1	Physical Science
2	Biological Science
3	Earth Science

4 Non science

Yrs

Column F – Years of Experience in teaching lower secondary science (Yrs)

1 1 year
2 2 years
etc

SA

Column G – Area of Teaching Speciality

1 Physical science
2 Biological science
3 Earth Science
4 Others – non science

Question 1 Teachers nearly always answered this question in point form often incorporating several answers (as separated below)

A1, 1B, 1C, 1D, 1E

Column

I 1A Prepares students for post-compulsory education (yr 11 and 12)

Post compulsory education – making specific reference to choosing science subjects and achieving in science subjects in Years 11 & 12 and pursuing science at higher levels of education ie Uni.

Quotes

"…..prepare them for post-compulsory studies in Yrs 11 & 12" - Teacher 2

" that eventually lead to upperschool and further educ." – Teacher 4

"… while providing a solid foundation for students who will pursue science further" Teacher 9

" To provide students with a strong science foundation to allow them the options of further studies" - Teacher 15

" A solid scientific background to achieve success in upper school science classes – Teacher 20 (case study teacher)

"to provide them with skills if they require it for future use (in tertiary/higher 2 education" Teacher 22

J 1B Helping students use science to interpret their world and make considered choices–Giving students enough general science to allow them to interpret and understand and make sense of the world around them, and their place in the world. Using science to make choices in the real world with regard to the interpretation of future decisions both related to career (non science specific) and simply everyday decisions.
Quotes

" Improve student understanding of science areas and hence allow them to choose future directions based on knowledge" Teacher 1

"provide solid science background for general life experiences and…." Teacher 2 (case study teacher)

" Provide a broad background to science so as students have a functional knowledge and skills in science to be able to adequately survive and interpret basic science in the society in which they live" Teacher 5

"To impart important concepts about the way in which the world works, so the students can make sense of their world" Teacher 7

"Enable students to understand more about themselves and their surroundings" Teacher 10

"For youngsters to become aware of the various aspects of the environment, themselves and understand the role they play in society" Teacher 12

"educating the students about the world around them and getting them to ask 'why' and 'how' questions about the world" Teacher 13 (case study?)

"… to underlie the importance of science in everyday life……the application of science in the environment and society" Teacher 19

"To provide our future adults with a general understanding of science concepts and a way of finding answers to their questions as well as an awareness of how society uses science" Teacher 21 (case study teacher)

"To provide students with an understanding of science so they are able to explain everyday experiences…" teacher 23

K 1C Develop an interest in science and fostering an enquiring mind.
Foster and promote an interest in science and enable students to develop an enquiring mind
Note this is nearly also coupled with enjoyment aspect of science or promoting interest that leads to wanting to understand and make sense of the world around them.

Quotes
"Develop an enquiring mind" Teacher 3

"To provide a level of scientific literacy that will produce a thirst for and interest in science….." Teacher 6

"To foster an interest in science ….." Teacher 8

" …encourage inquisitiveness about the natural world" Teacher 9

"Create interest in science in the students" Teacher 10

"…getting them to ask 'how' and 'why' questions about their world" Teacher 13

" …to encourage them to explore and ask questions rather than accepting things" Teacher 14

" and spark an interest so they will be life long-learners for science" Teacher 15

"To give students an insight into the intrigue of science and create a life long interest in asking why" Student 17

"To develop an inquiring mind and a life long love/appreciation of science" Teacher 20 (case study teacher)

L 1D Develop an understanding of general science principles Develop an understanding of general science principles for purely its own purpose. This was not stated as a reason for teaching science in many cases, most teachers saw that teaching science was a means to as end and therefore "a solid background" or an understanding of general science principles to lead to ….. is found in other answers especially relating to B the discovery of understanding of society and everyday life.

Quotes

"….build students concepts of scientific ideas" teacher 8

"Provide a general knowledge of the broad disciplines of science" Teacher 10

" Broad/comprehensive introduction to the various branches of science including Scientific Method. Simple applications of concepts and principles" Teacher 11

"exposure to many scientific fields" Teacher 20 (case study)

" developing sound understanding of rudimentary science concepts and skills" Teacher 25

M 1E Develop skills and science processes–To develop skills as independent learners and teachers who stated the importance of skills and the process of science as a stand alone.
These are answers that talk of the need only for students to have the skills.

Quotes

"The scientific approach in various contexts…" Teacher 4

"….. Scientific Method……." Teacher 11

" Skills necessary to become independent learners in science" Teacher 20 (case study)

" ..to develop the skills of logical planning, conducting, processing and evaluating primary and secondary data for application in wider areas of life. To develop applications of quantitative skills to practical situations." Teacher 24

"developing sound understanding of rudimentary science concepts and skills" Teacher 25

These quotes relate to teachers who state that skills are necessary in order to achieve other tasks
Teacher 5

N 1F Foster in students a love and an enjoyment of science

O 1G Enable students to relate their classroom science to their real life experiences

P 1 H Contribute to overall education and personal development of students

"Also contributing to the social and emotional development of students" Teacher 8

Question 2

A I believe science teaching is most effective when the teacher does the following

Q	2aA	Help students to contextualise science concepts into their experiences
R	2Ab	Enable students time to explore and experiment and perform practicals
S	2aC	Make classroom and activities motivating, interesting and fun for students
T	2aD	Chooses tasks and activities that are suited to students and abilities
U	2aE	Provide constructive (formative) assessment feedback
V	2aF	Forms good relationships with individuals

W	2aG	Can manage a classroom

Q2
B I believe science learning is most effective when the students do the following?

X	2b A	Students are interested, excited and enthusiastic about science
Y	2b B	Students are respectful and trust teacher
Z	2b C	Students ask questions, and participate in hands on experiments
AA	2b D	When children experience success and are motivated to study further
AB	2b E	Can develop into independent learners and take responsibilities as a learner
AC	2b F	Contextualise and relate science to everyday life
AD	2b G	Students can work collaboratively, interacting with teachers and peers

Q 3 Consider an ideal and an actual science lesson and allocate the percentage of time spent on both.

Ideal Science

Written as a percentage %

AE	3IA	Teacher explaining to whole class
AF	3IB	Whole class discussion
AG	3IC	Group-based practical and activity work
AH	3ID	Giving notes to students
AI	3IE	Students working individually included text.

Actual Science

Written as a percentage %

AJ	3AA	A	Teacher explaining to whole class
AK	3AB	B	Whole class discussion
AL	3AC	C	Group-based practical and activity work
AM	3AD	D	Giving notes to students
AN	3AE	E	Students working individually included text

Note b was put in if the respondent left the space blank or wrote depends or similar.

Q4
Ideal science

AO **4A** The major focus is completing Unit content
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AP **4B** The unit is organised around contexts and issues relevant to students
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AQ **4C** Students must follow experiments instructions given by the teacher very carefully to reach the correct conclusion
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AR **4D** Students plan their own experiments to investigate their own questions
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AS **4E** Practical work is used to illustrate the concepts that have been introduced
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AT **4F** Practical work is used to provide experiences of phenomena before concepts are introduced
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AU **4G** Students work in groups for most of their work
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs

5 Never occurs

AV **4H** Skills that enhance the effectiveness of learning in groups are taught explicitly

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AW **4I** Discussion is not encouraged, as a quiet classroom is the most productive

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AX **4J** Whole class discussion occurs at the conclusion of activities with the main ideas summarized.

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AY **4K** Assessment is used mainly for grading and reporting

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

AZ **4L** Assessment is mainly portfolios and work samples to determine where students are at and where to go next

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BA **4M** The reporting of students' progress is in levels for outcomes

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BB **4N** Students learn science that is relevant to their lives

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs

5 Never occurs

BC **4O** Students prior beliefs are considered when planning lessons

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BD **4P** Students have access to computers to research information

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

Q5
Actual science

BE **5A** The major focus is completing Unit content

6 Always occur
7 Occurs most of the time
8 Occurs some of the time
9 Seldom occurs
10 Never occurs

BF **5B** The unit is organised around contexts and issues relevant to students

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BG **5C** Students must follow experiments instructions given by the teacher very carefully to reach the correct conclusion

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BH **5D** Students plan their own experiments to investigate their own questions

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BI **5E** Practical work is used to illustrate the concepts that have been introduced

1 Always occur
2 Occurs most of the time

3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BJ **5F** Practical work is used to provide experiences of phenomena before concepts are introduced
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BK **5G** Students work in groups for most of their work
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BL **5H** Skills that enhance the effectiveness of learning in groups are taught explicitly
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BM **5I** Discussion is not encouraged, as a quiet classroom is the most productive
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BN **5J** Whole class discussion occurs at the conclusion of activities with the main ideas summarized.
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BO **5K** Assessment is used mainly for grading and reporting
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BP **5L** Assessment is mainly portfolios and work samples to determine where students are at and where to go next

1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BQ **5M** The reporting of students' progress is in levels for outcomes
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BR **5N** Students learn science that is relevant to their lives
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BS **5O** Students prior beliefs are considered when planning lessons
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

BT **5P** Students have access to computers to research information
1 Always occur
2 Occurs most of the time
3 Occurs some of the time
4 Seldom occurs
5 Never occurs

6 List 4 major factors that inhibit or limit the effectiveness of your lower secondary science teaching (Put a 1 in column to indicate teacher expressed that most important factor, 2 in column if teacher expressed factor as 2nd most important fact, 3 in column that expressed the next most important fact, and 4 in column if this was listed as teachers least important factor)

BU	6 A	Limited science resources ie teaching aids
BV	6 B	Time allocated to Lower Secondary science
BW	6 C	Class size
BX	6 D	Curriculum restriction
BY	6 E	Student poor attitude and behaviour
BZ	6 F	Teacher's attitude
CA	6 G	Extra- curriculum pressures, which reduces teachers preparation time
CB	6 H	Lack of access to technology
CC	6 I	Lack of parental support

CD	6J	Lack of science knowledge and skills of teacher
CE	6K	laboratory access
CF	6L	Differing student abilities within the same class, ie special needs students in mainstream
CG	6M	Coordinating LSS with large numbers of staff who all teach particular year group

7

1) CH 7U1 Increasing student's interest in science by setting lessons in real world context.

1) Not useful
2) Some what useful
3) Very useful – reasons stated

CI	7C1.1	Concern 1	Lots of extra work expected by teacher
CJ	7C1.2	Concern 2	Difficult to find meaningful contexts
CK	7C1.3	Concern 3	Reduce content covered
CL	7C1.4	Concern 4	Needs extra resources

2) CM 7U2 Formative assessment

1. Not useful
2. Some what useful
3. Very useful – reasons stated

CN	7C2.1	Concern 1 Teacher would be expected to control and moderate this task
CO	7C2.2	Concern 2 Not a useful assessment tool to teachers – no comparability
CP	7C2.3	Concern 3 Does not meet parent and administrations expectations
CQ	7C2.4	Concern 4 Time to administer and moderate task
CR	7C2.5	Needs more information- does not have enough information to have concerns

3) CS 7U3 Encouraging more student-centred learning

1. Not useful
2. Some what useful
3. Very useful – reasons stated

CT	7C3.1	Concern 1 Motivating and giving students skills to take control
CU	7C3.2	Concern 2 Lack of resources and time in curriculum

CV 7C3.3 Concern 3 Assumes good content background for teacher

CW 7C3.4 Concern 4 Extra work/time for teacher

CX 7C3.5 Concerns 5 Accountability to parents and admin.

CY 7C3.6 Concerns 6 This learning will allow too much specialisation and prevent more general/comprehensive education

CZ 7C3.7 Concern 7 Teachers would not have necessary skills

4) DA 7U4 Use of investigation to promote inquiry in the curriculum
   1. Not useful
   2. Some what useful
   3. Very useful – reasons stated

DB 7C4.1 Concern 1 Students not used to open investigations consequently need direction and skills.
DC 7C4.2 Concerns 2 Difficult and time consuming for teacher to set up and run

DD 7C4.3 Concerns 3 Time constraints of the LSS

DE 7C4.4 Concerns 4 Lack of adequate resources to set up small groups

DF 7C4.5 Concerns 5 Assessment concerns- teachers helping students so work is not their own work

5) DG 7U5 Use of investigation to promote inquiry in the curriculum
   1. Not useful
   2. Some what useful
   3. Very useful – reasons stated

Concerns. Put a 1 in column to indicate teacher expressed that concern, 0 in column if teacher did not express that concern

DH 7C5.1 Concern 1 Some rote learning of facts still deemed as necessary by teachers. Students required in order to learn concepts and terminology in order to master broader concepts, and remember specific facts.[1]

DI 7C5.2 Concern 2 Creates conflict with current requirements, both to cover specific lower school science objectives and prepare students for vast quantities of fact data to be learnt in some science upper school classes.

DJ 7C5.3 Concern 3 Consider student needs. All students' progress at different rates and therefore individual needs must be catered for.

DK 7C5.4 Concern 4 Teachers need time and skills to implement this.

DL 7C5.5 Concern 5 Changing students' expectations of what the meaning of being successful is. Ie Students have been used to being successful with recall of facts and rote learning.

6) DM 7U6 The use of information technology to enhance student learning

1. Not useful
2. Some what useful
3. Very useful – reasons stated

DN 7C6.1 Concern 1 Logistical issues. Lack of viable computers available (some schools do not have enough computers for all students to use, or those that are available are out dated, slow or broken and do not fit into the science classroom physically)

DO 7C6.2 Concern 2 Teachers expressed concerns that when computers were available they were used to the exclusion of other more appropriate resources.

DP 7C6.3 Concern 3 Not the best use of classroom time, as students tend to waste vast amounts of time setting up etc etc.

DQ 7C6.4 Concern 4 Need to monitor students use of computers. To prevent students from using material appropriately and plagiarising material as they're own, and accessing material that is inappropriate and unsuitable.

(Note School that I would consider to have the greatest access to computer resources had far more concerns about this innovation that the others suggested in Q7. Due in part to them actually trying to make it work in the classroom??)

Q8 What, if any are your concerns about your own teaching

DR 8.1 Concern 1 Ability to adopt and use different teaching strategies (ie student centred)

DS 8.2 Concern 2. Teacher morale and motivation. Teachers do not have the necessary energy to instigate and maintain any changes into teaching (Teacher 1).

DT 8.3 Concern 3 Ability to cater for students with different needs (ie. either high or low ability students in groups, or individually within the classroom)

DU 8.4 Concern 5 The teachers ability to manage time. Both within the classroom (ie planning lesson and leaving adequate time to conclude), and with the pressures of extra admin and extra curriculum activities.

DV 8.5 Concern 5 The expectation that students will need to learn a certain amount of key concepts and facts

DW 8.6 Concern 6 Lack of collegiality/support for teacher. Teachers do not have the collegiality and support of other teachers due to isolation and distance (teacher 7) or other reasons.

DX 8.7 Concern 7. Poor student behaviour. Teacher does not have the motivation to deal with poor student behaviour, and classroom activities shaped to manage classroom. Teachers report being unable to interact successfully with badly behaved students.

DY 8.8 Concern 8. Lack of science background knowledge and skills

DZ 8.9 Concern 9 Lack of IT expertise and resources.

EA 8.11 Concern 10 Lack of resources and reduced access to laboratory

Q 8 b What changes and improvements would you like to make to your teaching?

EB 8b.1 Increased communication and collaboration with other science teachers

"a better communication and collaboration with other science teachers" (Teacher 19)

EC 8b.2 Improved communication and empathy with the students. This is inside the classroom between students and teacher as well as outside of the classroom between teachers.

"improved communication" (Teacher 2)

"greater ability to empathise with students" (Teacher 8)

ED 8b.3 Increased curriculum control – Ability to control and direct the amount of material covered in the classroom and consequently be able to utilize any appropriate teaching strategy.

"Freedom to cultivate enquiry" (Teacher 3)

" to become more of a facilitator rather than be teacher-centered in the classroom" (Teacher 12)

" greater creativity… ……greater task variety" (Teacher 13)

EE **8b.4** Ability to improve students' interest and motivation. To gain the skills and motivation to deal with poorly behaved student.

" more student initiated responses to pursue their own interests in the topic" (Teacher 5)

"more ability/motivation with the poorly behaved low ability student" (Teacher 6)

"make it more interesting and exciting for stds" (Teacher 20 – case study)

" being able to engage students more in learning for their own benefit. Stirring up that intrinsic feeling of learning in students" (Teacher 25)

EF **8b.5** Focus on improving the skills of student.

"more focus on cognitive skills for skills" (Teacher 9)

"be able to incorporate computing skills into normal lesson" (Teacher 11)

EG **8b.6** Improving the (science) knowledge and skills of the teacher. Some teachers wanted information about specific areas ie learning strategies, assessment, practical activities.

" more understanding of the new assessment system" (Teacher 16)

" Learn different methods, be able to implement them efficiently and with ease" Teacher 21-case study)

EH **8b.7** Ability to manage class more effectively

"A more relaxed approach to student behaviour" (Teacher 8)

" be able to keep 'stroppy' girls onside. I can with boys who seem to respond better to science" (teacher 11)

"clear expectations – discipline" Teacher 14

EI **8b.8** To increase and improve the practical lessons

"more innovative practical ideas (I love to do practs with students)" (Teacher 15)

"more confidence and knowledge of enjoyable and interesting practical activities" (Teacher 10)

"more practical lessons" (Teacher 19)

EJ **8b.9** To be able to manage time more effectively and develop greater organisational skills

"more organised to finish the lesson – conclude" (Teacher 23)

" greater planning" (Teacher 13)

EK **8b.10** To contextualise the lesson for the students

"make it more relevant" (Teacher 20- case study teacher)

Q 9. What do you wish to achieve from this project?

EL **9.1** New teaching strategies/methodologies. Teachers seeking new ideas in the form of teaching strategies, skills and methods to implement into their classroom in a practical way.

"something I can take into my classroom and use as a platform for my lessons" (Teacher 4)

"an approach to energy that provides students with a continually challenging and motivating course" Teacher 6

"to further improve my student-centeredness of my classroom" Teacher 7.

"I guess to extend my ideas of strategies that can be used in outcomes focussed classroom" Teacher 9

"learn new, interesting experiments and teaching skills to improve the learning experiences of my students" Teacher 10

"a more constructivist approach to science" Teacher 23

EM **9.2** More resources. Teacher seeking new resources in the form of materials, web sites and practical equipment.

" Support material for teachers" Teacher 4

"With support material and extra resources I am looking forward to enhancing the responsibility of the student for their own learning with me being a facilitator rather than a dictator" Teacher 7

" increases in resources and assessment tasks for energy" (Teacher 13 CS)

EN **9.3** Increased information about existing innovations. Consequently leading to a better understanding of a number of innovations currently being implemented. Becoming in touch with modern teaching theory was also incorporated into this question.

" a better understanding of curriculum framework assessment approaches" Teacher 5

" greater understanding in Science department of student centred learning .." Teacher 8

" greater direction with SOS (student outcome statements)" Teacher 13 CS

EO **9.4** Greater collegiality. A better sense of team work between Year 9 teachers to work collaboratively together

"Greater team work with Yr 9 teachers" Teacher 8

EP **9.5** Non specific help. The teacher needed help but was non specific about the nature of the help, ie strategies, resources etc. (Seemed to want spoon feeding rather than new strategies.)

"more interesting, productive sessions with Year 9's" Teacher 18

"a clear understanding of what I have to teach for the unit energy" Teacher 14

"producing a good energy and change unit to engage students and encourage scientific enthusiasm" Teacher 22

"develop and use ideas of a different kind" (Teacher 1)

EQ **9.6** Reassess effectiveness. A reassessment of whether or not teachers are effective in the classroom.

" We have modern text resources, modern philosophical viewpoints, the desire and commitment to be excellent teachers. Our training occurred long ago. We need to be able to objectively assess what we do and how we do it in respect to effectiveness" Teacher16
Q10 What will /hinder you in reaching this goal?

EK **10.1** Hinder. Teacher's approach and motivation. Teachers concerns that they have the most effective approach and then energy and motivation to implement the approach into the curriculum.

"Confidence in my own skills and knowledge to carry out parts of the program" Teacher 10

"my approach" Teacher 6

EL **10.2** Hinder Lack of Resources

EM **10.3** Hinder - School administration – the school admin., education department and others which determine curricula to be covered etc.

EN **10.4** Hinder - Students. Either in their lack of ability or lack of motivation/interest

10.5 Hinder - Time restrictions

"Time" Teacher 9

"only my inadequacies ie time …." (Teacher 7)

"having enough time to focus on it fully" Teacher 21 (case study)

EN **10.6** Help – By new resources and strategies that are available to teachers.

EO **10.7** Help – By collegiality between teachers and the shared common goal

Q11. What do you hope your students will gain from this project?

EP **11.1** Understanding of the concepts in Energy and an understanding of how energy relates to students everyday activities

"a level of scientific literacy appropriate for a Year 9" Teacher 6

EQ **11.2** Skills and strategies to be more independent learners

"a level of scientific literacy appropriate for a Year 9" Teacher 6

ER **11.3** Improved interest, motivation, enthusiasm for science.

ES **11.4** Better curriculum and lessons for individualisation for students

" some consistency in curriculum, consistent teacher approach/expectations" Teacher 4
"a set of good lessons given to them in third term..." Teacher 11

" the more strategies I have to use in my classroom the more opportunities I can open for them" Teacher 9

Good Quote

" an enjoyment of discovering things for themselves which leads to an understanding of underlying concepts" Teacher 7

" greater understanding, involvement, interest and enjoyment of science. Higher skill levels in group work and inquiry and better work habits" Teacher 8

Appendix 5.1 Worksheet 1

Colour of Light

A mystery unravelled (Complete the quotation once you have finished the activity.)

In the year 1666……. I procured me a triangular glass prism … having darkened the chamber and made a small hole in my window shut, to let in a convenient quantity of the sun's light, I placed the prism at the entrance and saw

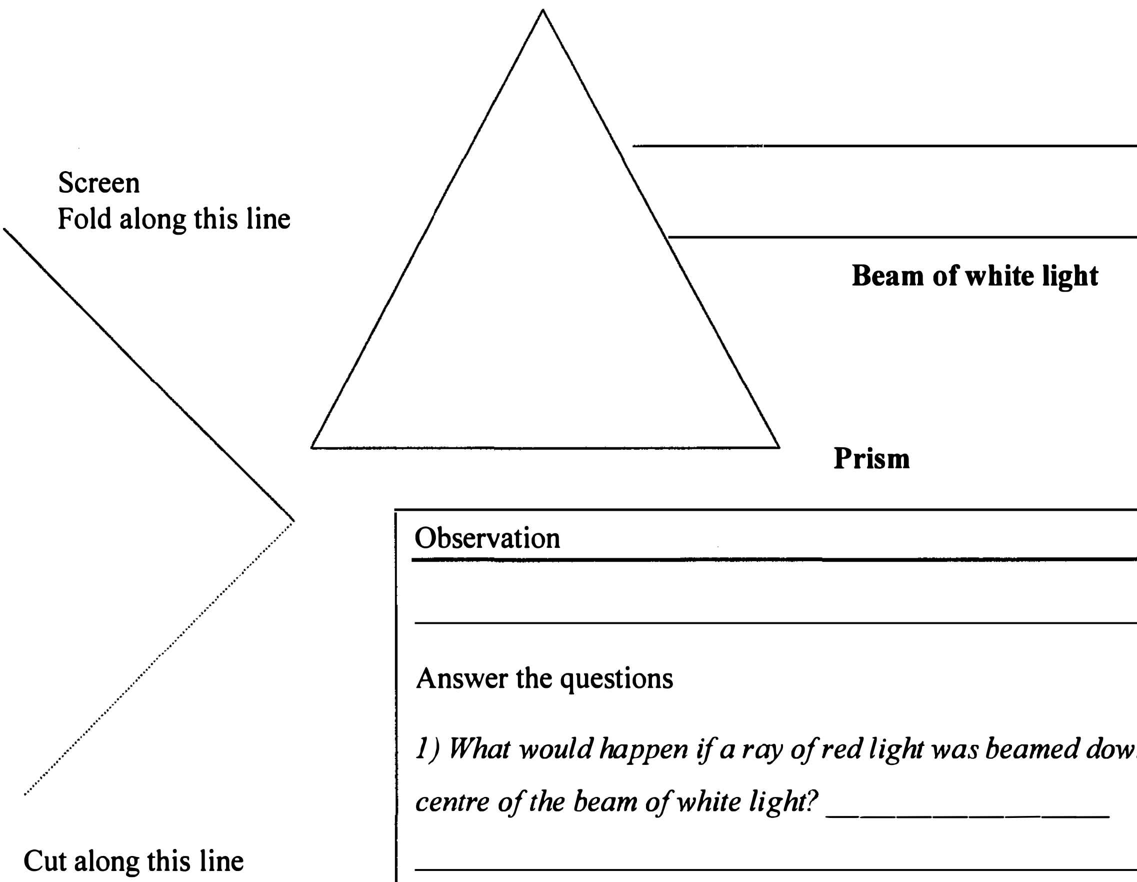
____

____

____

(Isaac Newton)

Set up the equipment as shown in the diagram



Observation ____

____

Answer the questions

1) What would happen if a ray of red light was beamed down the centre of the beam of white light? __________________

____

2) Explain what could happen if a prism was placed where the screen is. ____

____

3) What colour is refracted least by the prism? ___________

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